



Accounting for national and corporate ecological debt, a steering tool towards a sustainable economy

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Accounting for national and corporate ecological debt, a steering tool towards a sustainable economy

***Translated from the original version:** La comptabilité des dettes écologiques
nationales et d'entreprises, un outil de pilotage vers une économie durable*

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and the co-supervision of **Clément FEGER**, Senior Lecturer

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Titre: La comptabilité des dettes écologiques nationales et d'entreprises, un outil de pilotage vers une économie durable

Mots clés: Comptabilité nationale, biodiversité, comptabilité d'entreprise, durabilité

Résumé: Malgré de nombreuses avancées, les crises écologiques et climatiques restent des défis moins bien gérés par la puissance publique que les questions purement économiques. Bien qu'étant encore largement structurante pour soutenir la puissance publique dans le traitement de ces derniers enjeux, la comptabilité nationale a rencontré des limites (critiques du PIB considéré comme un indicateur obsolète pour mesurer la richesse, difficultés face à la mondialisation des échanges) qui ont affaibli sa portée comme outil de planification. L'absence de prise en compte de l'enjeu environnemental est une des limites souvent mentionnées. À ce jour, aucune des propositions d'intégration de l'environnement dans la comptabilité nationale ne parvient encore à s'imposer comme outil d'appui à la prise de décision. Manque de légitimité, relative déconnexion aux politiques publiques, cadrages selon les principes de la durabilité faible ou grande part de modélisation sont autant de raisons qui affaiblissent, par exemple, les nouveaux indicateurs de richesse, l'épargne véritable ou le Système de comptes économiques et environnementaux de l'ONU. L'objectif de cette thèse est d'outiller l'action publique avec une comptabilité nationale qui permette de conduire une transition écologique. Nous tenterons de montrer pourquoi et comment articuler des dettes et créances écologiques du niveau des

entreprises au niveau national peut créer un outil de représentation et de discussion adéquat. Ce travail est fondé sur des incursions dans l'histoire de la comptabilité nationale économique française pour comprendre pourquoi une articulation entre niveau national et niveau organisationnel fut mise en place. Cet héritage sert de point de repère pour questionner les opportunités d'une extension comptable environnementale similaire. Deux politiques liées à la biodiversité sont discutées: la gestion des milieux aquatiques et celle de la biodiversité terrestre. Par ailleurs, parce que la quantification de l'environnement (notamment en termes monétaires) est sujette à controverse, nous analysons conjointement conventions comptables et modèle de gestion sous-jacent (implicites ou explicites). Ces travaux mettent en lumière l'intérêt d'articuler les dettes écologiques nationales et d'entreprise pour éviter un recours massif à la modélisation pour estimer des valeurs monétaires liées à l'environnement. Nous montrons aussi que cela peut considérablement renforcer la planification et la gestion des transitions vers une économie soutenable, en cohérence à ces deux niveaux. Enfin, fonder de telles comptabilités sur des politiques existantes permet de bénéficier d'une légitimité politique complémentaire à la pertinence scientifique revendiquée par notre approche.

Title: Accounting for national and corporate environmental liabilities: a steering tool towards a sustainable economy

Keywords: National accounting, biodiversity, business accounting, sustainability

Abstract: Despite many advances, the ecological and climate crises remain challenges that are less well managed by public authorities than purely economic issues. Although still largely structuring to support public power in dealing with these latter issues, national accounting has encountered limitations (criticism of GDP as an obsolete indicator for measuring wealth, difficulties in the face of trade globalisation) which have weakened its scope as a planning tool. The failure to take account of environmental issues is one of the limitations often mentioned. To date, none of the proposals for integrating the environment into national accounting has yet managed to establish itself as a tool to support decision-making. Lack of legitimacy, relative disconnection from public policies, framing according to the principles of weak sustainability or a high degree of modelling are all reasons that weaken, for example, the new wealth indicators, genuine savings or the UN System of Economic and Environmental Accounts. The objective of this thesis is to equip public action with a national accounting system that allows for an ecological transition. We will try to show why and how articulating ecological debts and claims from the corporate to the national level can create

an adequate tool for representation and discussion. This work is based on forays into the history of French national economic accounting to understand why an articulation between national and organisational levels was put in place. This legacy serves as a benchmark to question the opportunities for a similar environmental accounting extension. Two biodiversity-related policies are discussed: the management of aquatic environments and terrestrial biodiversity. Furthermore, because the quantification of the environment (particularly in monetary terms) is controversial, we analyse accounting conventions and the underlying management model (implicit or explicit) together. This work highlights the value of articulating national and corporate environmental liabilities to avoid a heavy reliance on modelling to estimate monetary values related to the environment. We also show that this can considerably strengthen the planning and management of transitions towards a sustainable economy, in coherence at both levels. Finally, basing such accounts on existing policies provides a political legitimacy that complements the scientific relevance claimed by our approach.

Disclaimer

This version is an English translation of the original thesis manuscript written in French. **The French version is authoritative.** The author has made a number of corrections, but errors may remain in both form and content. This text has not been fully proofread by the author, nor by a professional. Nevertheless, this text can be cited as is.

In case of doubt, please refer to the French version.

The translation was carried out using DeepL. Five figures and one table that are not essential to understand the text have not been translated. Some quotations were translated into French and then back into English. They may therefore differ from the original version. Some technical terms and acronyms have been translated by the author using the glossary function of DeepL. The most important are as follows:

<u>French</u>	<u>English</u>
actif	asset
capital	capital
dette	debt
passif	liability
immobilisation	fixed asset
investissement	investment
évaluation monétaire	monetary valuation
monétarisation	monetary valuation
Éviter, réduire, compenser (ERC)	Avoid, minimise, restore, offset (AMRO)
Étude d'impact	Environmental impact assessment
Zéro artificialisation nette	No net land-take

Certain terms such as "capital" or "valuation" do not have exactly the same meaning in French and English. Moreover, they can lead to confusion within the same language. The author has endeavoured to define and discuss these concepts where necessary.

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Production and scientific activities

Scientific articles published in international peer-reviewed journals

- Surun C. & Kervinio Y. (1st authors), Comte C., Levrel H. [Defining ecological liabilities and structuring ecosystem accounts to support the transition to sustainable societies](#). One Ecosystem.
- Comte A., Surun C., Levrel H., 2023. [Measuring and managing for environmental sustainability. An application of the Environmental Sustainability Gap \(ESGAP\) framework in New Caledonia](#). Environmental Science & Policy.

Other scientific productions

- Comte, A., Surun, C., Levrel, H., 2021. La mise en œuvre de l'indicateur ESGAP en Nouvelle-Calédonie. Chaire Comptabilité Écologique. hal-03142104v2
- Comte, A., Surun, C., Levrel, H., 2021. Measuring and piloting the strong sustainability of a territory - the implementation of the ESGAP dashboard in New Caledonia. WWF France.

Conferences

- London Group on environmental and economic accounting, 2022. "[Toward the inclusion of ecological liabilities in the system of national accounting: first proposals](#)". Surun C., Kervinio Y., Comte A., Feger C., Levrel H. Siegburg, Germany
- Invited speaker at the annual conference of the INSEE-Paris School of Economics chair "Beyond GDP", 2022, "Integrating the environment into national accounting: micro-macro articulation of ecological debts", Surun C., Gonon M., Comte A., Kervinio Y., Feger C., Levrel H. Paris, France.
- Ecosystem services partnership, 2021, "[Monetary valuation in the history of the SEEA: hesitations between strong and weak sustainability](#)" Surun C., Feger C., Levrel H. Tartu, Estonia.

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- Lecturer in the "Introduction to environmental national accounting" course as part of the Ecological Economics teaching unit of the Master 1 in Environmental Management at AgroParisTech, in 2022 and 2023.

Abbreviations

AMRO	Avoid, minimise, restore, offset
BA	Business accounting
BEA	Bureau of Economic Analysis
CA	Correspondance analysis
CARE	Comprehensive accounting in respect of ecology
CDC	Caisse des Dépôts et Consignations
CEREMA	Centre d'études et d'expertise sur les risques, l'environnement, la mobilité et l'aménagement
CF	Central Framework
CFC	Consumption of fixed capital
CGDD	Commissariat Général au Développement Durable
CGP	Commissariat général au Plan
CNIS	Commission nationale de l'Information statistique
CSRD	Corporate sustainability reporting directive
DEB	Direction de l'Eau et de la Biodiversité
EA	Ecosystem accounts
EBITDA	Earnings before interest, taxes, depreciation, and amortization
EEA	European Environmental Agency / Experimental ecosystem accounts
EIA	Environmental impact assessment
FAO	Food and Agriculture Organisation
FC	Final consumption
FDES	Framework for the Development of Environment Statistics
GAAP	Generally agreed accounting principles
GFCF	Gross fixed capital formation
GG	General Government
HH	Households
IASB	International accounting standard board
IBD	Indice biologique diatomées
IC	Intermediate consumption
ICPE	Installations classified for the protection of the environment
IFRS	International Financial Reporting standard
IMF	International Monetary Fund
INSEE	Institut nationale de la Statistique et Etudes économiques
IPBES	International Platform for Biodiversity and Ecosystem Services
IPR	Indice poissons rivière
LEMA	Loi sur l'eau et les milieux aquatiques
LG	London Group
MSA	Mean species abundance
MTE	Ministère de la Transition écologique
NA	National accounting
NAFA	Natural, agriculture and forest areas
NNL	No net loss
NPI	Non-profit institutions
PSH	Protected species and habitats
SNWA	Seine-Normandy Water Agency
TC	Technical committee

UEC	Unpaid Ecological Costs
UN	United Nations
US	United States or Undeveloped surface
WA	Water Agency
WB	World Bank
WFD	Water Framework Directive

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General introduction

1. National accounting, a political object?

In its most general sense, accounting involves designing and using information systems to organise collective action (Feger, 2016). Many authors from the accounting discipline (Chapman et al., 2009; Feger et al., 2018; Hopwood and Miller, 1994; Miller, 1986; Richard et al., 2018; Roberts and Scapens, 1985) or the sociology of quantification (Desrosières, 2008a; Espeland and Stevens, 2008) show that accounting is not a neutral tool. On the contrary, they are intimately linked to historically situated visions of the world and to the models of action espoused by those in power. Accounting is therefore much more a social practice than a neutral, timeless tool. We can therefore study the way in which accounting concepts are created and, once their definition and uses have become relatively stable, how they shape the practices of their users, in particular by making "certain areas of social life practicable" (Miller, 1986).

Today, we naturally think of areas of application such as business or administration, and sometimes the national economy. In reality, history has seen the emergence of forms of accounting adapted to much more varied problems: accounting for trade in Mesopotamia (which appeared before writing), accounting for relations between the worlds of the living, the dead and the gods in ancient Egypt, accounting for expenditure from the Athenian treasury, accounting for sins by the Jesuits of the Society of Jesus (XV^e century), accounting for slaves (for their management or in the service of the abolitionist cause), accounting for whales for the oil industry (XVIII^e and XIX^e centuries), accounting for the bare minimum (to live in autarky) by Henry David Thoreau (Feger, 2022, 2016; Soll, 2014).

In 1494, the monk Luca Pacioli described a double-entry bookkeeping system, a major innovation for Venetian merchants of the Renaissance. This gave them a distinct advantage when it came to setting up the first international commercial and financial companies. Business accounting has subsequently evolved according to the dominant economic players, historical periods and countries. The concept of accounting profit or loss is one example (Richard, 2012a; Richard et al., 2018). If we look at what is not included in current expenses, we can guess who the profit is intended for: the shareholder-owner (countries where capitalism dominates), the State (communist countries), the workers (former Yugoslavia). Similarly, the way in which the amounts are calculated is not neutral and creates an advantage for specific players: Renaissance bankers favoured valuing assets held at the current market price to keep an eye on what they could make from a liquidation; company managers preferred to value assets at historical purchase cost, to keep track of how capital was used, with a view to paying it back over time; since the 1970s, shareholder-owners have been campaigning for the value of these assets to be calculated by summing up the future income that can be expected from them, to know which company to invest in (Richard, 2012a; Richard et al., 2018).

Because accounting is not the thing it represents, and because we cannot represent everything, selecting the dimensions to be measured is a necessary step. As with any quantification exercise, complete neutrality, pure objectification, is not possible (Desrosières, 2008a). In order to make representation choices, as in the design of public policies, we therefore need to refer to more general "cognitive representations". These representations include the formulation of a problem, its consequences and possible solutions to remedy it (Muller, 2018). It is thus necessary to choose the relevant elements of reality that we are going to quantify and construct the accounting categories that are going to record them.

National accounting, created between the 1930s and 1960s, is a "comprehensive, detailed and quantified representation of the national economy within a balanced accounting framework" (Piriou

et al., 2019). Its flagship indicator is Gross domestic product (GDP)¹. As an accounting system, it is not immune to what we have just written.

Thus, at national level, Miller (1986, p. 95) points out that "accounting concepts are developed in parallel with idealised programmes for governing society" (or "idealised schemes for regulating social life"). He points out that a programme does not have to be applied literally, but is rather "a space in which competing objectives and interests can be discussed and worked out" (ib.). National accounting then serves to clarify and concretise this programme. More generally, National accounting and political economy can even be compared in terms of the issues they deal with in common: "increasing the power of the State and the resources of the nation by opening up a new field of knowledge directly useful to the State" (Miller, 1986, p. 83).

François Fourquet (1980) describes France's post-war programme, for example: "growth, modernisation and the promotion of everything productive" (Miller, 1986, p. 91). The British had "another dream for society, based on the notion of full employment as an objective of economic policy" (Tomlinson, 1981, quoted by Miller, 1986, p. 95) and thus a National accounting system adapted to this objective, developed by Meade and Stone².

It was at this time that GDP became the main indicator for guiding government intervention (Fourquet, 1980; Vanoli, 2002). It was not, of course, the only indicator used, but it gained a central place. Since the 1940s, this indicator has been the subject of debate over its interpretation (van den Bergh, 2009). From the 1970s onwards, these discussions became more widely echoed criticisms, reaching a particularly visible peak around 2010. This movement began in 2007, with a conference organised by the European Union, the Club of Rome, the OECD and WWF (European Commission and European Parliament, 2009). In 2008, French President Nicolas Sarkozy commissioned three economists, Joseph Stiglitz, Amartya Sen and Jean-Paul Fitoussi, to reflect on the limits of GDP and propose alternatives. They set up the Commission on the Measurement of Economic Performance and Social Progress, which published its conclusions shortly afterwards (Stiglitz et al., 2009a). In France, a socio-political initiative was launched at the same time, the Forum pour d'autres indicateurs de richesse (FAIR, 2009). Building on work begun in the 1990s (Méda, 2020, 1999), the latter subsequently acknowledged the quality of the Stiglitz report's findings, but criticised its conclusions for being too biased on the part of the economists who took part in it, and for the lack of ambition in its proposals (Jany-Catrice and Méda, 2011). The "very official recognition that GDP is not an indicator of well-being" (ibid.) was a major step forward that helped to (re)launch a current of "beyond-GDP" research that is still active at international level (Bagstad and Fox, 2021; Bleys and Thiry, 2022; Chancel et al., 2014; Fleurbaey, 2015; Fleurbaey and Blanchet, 2013; Hoekstra, 2019; Landefeld et al., 2020; OECD, 2018a; Radermacher, 2015; van de Ven, 2015).

¹ It is important to remember that National accounting is not the same as government accounting. The former represents monetary flows and stocks between all the players in the economy (businesses, financial institutions, Households, associations, government departments and the Rest of the World). The State accounts contain only the revenues, expenditure and assets of the State as an administration (for a detailed comparison, see Kott, 2017). This thesis does not deal with government accounting.

² The latter had a more macro viewpoint than the French and did not seek growth for its own sake, but worked on cyclical adjustments within a more global framework to maintain employment (Miller, 1986). The French, because they were trying to reconstitute the major 'productive' sectors, industry, thanks to a system of governance provided by the Plan, needed an intermediate information system between the micro and the macro, with more detailed information than in England (ibid.).

The non-technical criticisms can be grouped into three categories³. The first can be formulated as follows: everything that generates value added increases GDP, without any link to well-being. For example, repairs (e.g. health spending, environmental restoration) increase GDP, which at first sight leads to surprising results. Road accidents fuel growth through the cost of emergency and medical services, the purchase of a new car, and so on. Similarly, damage to well-being or the environment is not deducted. The second criticism concerns what is not included in GDP (and by extension, in National accounting): free time, voluntary work, Households work that can be assimilated to services (in particular household chores, cooking, DIY, family transport)⁴, the informal economy (particularly important in the countries of the South) or the illegal economy. A third criticism is that the total value of income generated (GDP) gives no idea of its distribution, and therefore of trends in inequality.

With these criticisms, it is easier to grasp the political nature of GDP: among the elements that characterise an economy, what does it represent and why? To date, the environment has been neglected, domestic work is not considered to be productive, and it is not easy to relate inequalities to other macroeconomic variables.

Faced with these criticisms and the fact that GDP sends out the wrong signals, some people are even proposing that GDP should no longer be used at all, or even that it should not be produced at all (Lachaize and Morel, 2013; VVan den Bergh, 2009). We would then replace everything it is supposed to represent with truly appropriate indicators: national power with the size of the armed forces (hard power) or the trade surplus (soft power), well-being with surveys of perceived happiness, the effectiveness of public policies with ad hoc indicators of the achievement of certain targets, and so on. Although it opens up the possibility of interesting additions, such a frontal rejection of GDP may seem excessive. Indeed, it has many qualities that are difficult to do without (Blanchet, 2022; Fleurbaey and Blanchet, 2013; Fourquet, 1980; Lachaize and Morel, 2013; Stiglitz et al., 2009a; Vanoli, 2002). As well as being three-dimensional (equal to final output, income and consumption), it is comparable over time and between countries. It gives a certain idea - imperfect, but not absurd - of the power, wealth, progress and material well-being of nations. It is a standard of comparison for other economic quantities. As an aggregate indicator of income, it is used for a number of institutional purposes, such as countries' contributions to international budgets (EU, OECD, UN), or the direction of international financial aid (from the IMF, the World Bank or national development banks in particular).

The criticisms cited above are nonetheless valid. In particular, very little use is made of National accounting to manage the ecological crises we are experiencing. Yet the necessary transitions towards a sustainable economy involve the coordination of companies in various sectors, General Government, Households, finance and international institutions. All are, and will increasingly be, called to account for the actions taken, the results achieved, the costs incurred, and the aid and compensation given or received. This was the *raison d'être* of National accounting after the Second World War. So can it be used again to reduce the pressure on the climate and biodiversity? How can national accounting address environmental issues? And in this context, what future does GDP have?

³ VNPV (2009) has produced a comprehensive summary. See also the book by Gadrey and Jany-Catrice (2016) for a more accessible version, or the article by Jany-Catrice and Méda (2011).

⁴ For an explanation of this point, see the System of national accounts 2008 (United Nations et al., 2011, para. 6.26-6.37).

2. Can National accounting be transformed to manage the ecological crisis?

This thesis takes as its starting point the environmental dimension of the criticism of GDP and will attempt to provide some answers. However, we will go beyond GDP alone and look at National accounting as a whole. Indeed, we believe it is important not to stop at this indicator alone, by demystifying its place in public policy. Going beyond this opens up a wider field of innovation, which will undoubtedly lead to more promising solutions.

While GDP is the accounting indicator that most reaches the general public through the media or political channels, it is far from the only one that guides economic policy decisions. Institutional users (ministries, Banque de France, etc.) and experts (economists, forecasters, etc.) rely on a wide range of information and indicators found in National accounting and government statistics. To name but a few: savings, investment, inflation, unemployment, debt, public spending, trade balance, exchange rates⁵. Furthermore, it is debatable whether GDP growth is the only objective of society. Productivism was very much in evidence after the Second World War, with a view to rebuilding destroyed economies and increasing national power (Fourquet, 1980). But other objectives soon emerged (Pottier, 2018; Timbeau, 2022) These include the search for a better distribution of wealth, with the creation of redistribution and a welfare state; the search for Keynesian equilibria, which may seek to curb demand so that it does not exceed supply; and the reduction of unemployment, which has recently been achieved not by the search for growth, but by reducing working hours or making the labour market more flexible.

In our view, this disqualifies the first solution proposed by those who criticise GDP, namely to correct it by adding or subtracting elements linked to the environment. Several economists have proposed this in various forms⁶. Most often, they suggest adding the contribution of the environment to production, or subtracting the value of its degradation or associated restoration expenditure. In this case, everything hinges on the idea that amounts reflecting economic values linked to the environment need to be added to GDP in order to produce a **green GDP**. In the words of Desrosières:

"[...] the debate on the "need to go beyond GDP" is situated [...] in a perspective of generalised commensuration, since the desired indicator would aim to aggregate, or at least "take into account", as many elements as possible that are supposedly ignored by traditional GDP: the environment (climate, biodiversity), unpaid work, inequalities, etc. according to the principle: 'Beyond GDP: reconciling what counts and what we count'" (Desrosières, 2014, p. 15).

Modifying GDP is problematic, as it would blur the important information it provides on production, income and consumption. A green GDP also means aggregating environmental issues into a single

⁵ If we had to use a simple metaphor, we could say that you don't drive a car with blinkers on that allow you to see only the speedometer. In addition to the quantified information that appears on the dashboard (engine revolutions per minute, fuel gauge, engine temperature), a driver relies on a number of qualitative pieces of information that are sometimes much more important. In particular, they use indicator lights, the guidance system and the presence of other motorists or obstacles on the road. Speed is a factor that is constantly in our minds, but it can never be interpreted in isolation. What's more, increasing speed to reach your destination quickly is not always the only objective. You may also want to ensure the comfort of your passengers first and foremost, or stop along the way to discover the richness of a region.

⁶ In particular, the sustainable economic development index (Nordhaus and Tobin, 1972), sustainable economic well-being (Daly et al., 1994) which gave rise to the genuine progress indicator (Lawn and Sanders, 1999) or attempts to calculate a green GDP (Committee of Experts on SEEA EEA, 2021; Hueting, 1980; United Nations, 1993a).

indicator. In this way, it becomes possible to compensate for a decline in environmental quality by increasing economic output. On the other hand, the metaphor quoted above suggests that the human mind does not need such an aggregated summary to guide economic policies: it can perfectly well rely on an accounting dashboard bringing together two to ten key indicators. We will therefore choose an approach based on accounting as a whole, extending it to include, as adequately as possible, essential elements relating to the environment.

Other authors have followed this second approach, which consists of constructing alternative indicators to complement GDP. They are based on the observation that the place of the environment in National accounting is problematic. Indeed, the aggregates conceal the economic flows linked to it. Environmental expenditure and goods and services are buried in production, while green taxation is included in the taxes and subsidies account. Environmental stocks are restricted to mineral natural resources that are "economically exploitable in their present state" (United Nations et al., 2011, para. 10.179) and cultivated biological resources. Non-cultivated biological resources (fish, forests) are only taken into account if they are exploitable or likely to be exploitable in the near future (United Nations et al., 2011, para. 10.182). The solution which consists of individualising this information and including it in **satellite accounts** (United Nations et al., 2014a) remains limited, although necessary. It relates only to transactions that have already taken place, or to the current state of stocks. Many aspects of the environment, such as biodiversity and climate, are not covered.

Under these conditions, it is impossible to properly assess the sustainability of an economy, i.e. to make an "assessment of the distance separating our current situation from these sustainable objectives" (Stiglitz et al., 2009a, para. 150).

Another, more interesting solution for translating the notion of sustainability is to construct or correct indicators other than GDP to account for **over-consumption or under-investment in environmental stocks**. This is the recommendation of the Stiglitz Commission (Stiglitz et al., 2009a, para. 150)⁷. In fact, this brings together a fairly wide range of accounting innovations: they may involve indicators or dashboards, which may be biophysical or monetary, and which are more or less integrated into the National accounting framework.

The Stiglitz Commission cites what it considers to be two good, albeit imperfect, candidate indicators. The first is real savings, or adjusted net savings (Hamilton, 2000). This involves correcting gross savings by subtracting the Consumption of fixed capital (the wear and tear on assets held), but also adding current expenditure on education (which increases 'human capital')⁸, and removing the depletion of natural resources⁹ and the degradation linked to global pollution¹⁰. This indicator is supposed to reflect the true accumulation of wealth. The second is the ecological footprint, which consists of aggregating environmental consumption into a single figure whose unit is the average bioproductive hectare. (Wackernagel et al., 1999). There are two versions of this indicator for the general public: the day we exceed our Kyoto target and the number of planets needed to generate the resources actually consumed. However, the ecological footprint is not part of National accounting and, according to the Stiglitz Commission, it makes more sense on a global scale.

⁷ Its full name is the Commission on the Measurement of Economic Performance and Social Progress.

⁸ In National accounting, this expenditure is consumption.

⁹ Estimated by the income derived from their extraction.

¹⁰ In fact, only greenhouse gases.

The main weaknesses of these indicators are the aggregation conventions used (Fleurbaey and Blanchet, 2013). These overvalue greenhouse gas emissions, while certain environmental issues are minimised or absent. Genuine savings have also been criticised in the same way as green GDP: they combine economic, social and environmental dimensions in a single indicator, allowing them to be substituted for each other (Neumayer, 2013). It is therefore a weak approach to sustainability.

Faced with these problems, and while waiting for a better indicator to be proposed, the Stiglitz Commission recommended another, less aggregated approach: to construct an official **scoreboard** bringing together environmental indicators, both monetary and non-monetary, and to include GDP in it, so that they can be discussed jointly (Stiglitz et al., 2009a). This is what gave rise to the ten national wealth indicators in France¹¹. This first step, while essential for managing complex crises, also brings its share of difficulties (Stiglitz et al., 2009a, para. 135). The indicators are heterogeneous and weakly linked, which prevents in-depth analysis. The lack of integration with National accounting means that these indicators are not as widely recognised and used as GDP. For Timbeau (2022), the interest of the Eva Sas law, which creates this dashboard, lies essentially in the injunction to "produce information that increasingly covers the important debates in society". In other words, this law endorses the idea that growth is not society's only objective, but without providing a tool to match GDP.

Have the accounting proposals already been exhausted? Is it not possible to go further and propose an extended national accounting system that would be genuinely useful in shedding light on the ecological transition?

3. Issues and approach

In the light of these mixed findings, the Stiglitz, Sen, Fitoussi commission suggested ways of quantifying the sustainability of an economy (Stiglitz et al., 2009a, p. 79). This would require:

- "To arrive at a limited number of indicators - a "micro" dashboard specifically devoted to assessing sustainability, based on a clear understanding of this concept;
- Explain the normative consequences of weighting, or avoid it;
- Avoid too close a relationship with GDP, which is a source of confusion (should you use GDP or green GDP? Which should you use in which context?);
- Draw up a consensus list of the dimensions whose sustainability we wish to assess.

The aim of this thesis is to demonstrate that the concept of ecological debt, defined at company level by Richard (2012b) and Rambaud and Richard (2015) and at National accounting level by Vanoli (2017, 1995) meets these requirements. We will also attempt to show that it is capable of being a complement to GDP that goes beyond genuine savings, the ecological footprint and an indicator dashboard.

To do this, we need to specify, at least succinctly, what we mean by sustainability. Here we take up the position adopted by Feger et al. (2021b) and Rambaud et Richard (2015).

¹¹ They include: employment rate, research spending, public and private debt, healthy life expectancy, overall life satisfaction, income dispersion, poverty rate, early school leavers, carbon footprint, land artificialisation. They are published by INSEE and can be consulted at the following link (01/2023): <https://www.insee.fr/fr/statistiques/3281778>

The concepts of sustainable development or sustainability are benchmarks that guide action towards a desired state of the economy and, more broadly, of society. These are very generic terms that need to be both qualified and made operational by specifying the principles of action to be followed, building tools, particularly for quantification (indicators, accounting), and adopting appropriate governance. These elements have been the subject of many academic discussions.

We would like to mention one point in particular, which involves going further than the general definition of sustainable development¹². To do this, we need to look at a key issue: can natural capital be substituted for social and economic capital? Here we will follow the principles of strong sustainability, which answers this question in the negative:

"The aim of strong sustainability is to go beyond these conventional definitions of sustainable development by considering that it is necessary to adhere to the constraint of maintaining natural capital, whether for ethical or technical reasons." (Feger et al., 2021b, p. 5)

As we shall see below, this naturally leads us to the idea of ecological debt, which gives concrete form to the notion of strong sustainability and makes action programmes to achieve it actionable.

This work acknowledges an important limitation of the debates that took place around the Stiglitz Commission, highlighted by Pottier (2018) the discussions remained essentially technical on the form that a new indicator or dashboard should take. Very little, if any, attention was paid to how the adoption of such an indicator would transform society. The idea that macroeconomic indicators are performative, i.e. that their presence and use almost automatically bring about change, concealed the effect of the incentives and utilitarian motivations of economic actors on the fate of the economy. In other words, "if we want a wealth indicator other than GDP to result in social transformation, we need to think about how this indicator will change the behaviour of economic agents" (Pottier, 2018, p. 154)..

This leads us to consider the introduction of ecological debts from two new perspectives: on the one hand, to study whether and how the State can use this indicator as part of the design and evaluation of public policies aimed at influencing economic players. In other words, we want to study in which decision-making circuits this indicator can be mobilised to produce change at the level of the State itself, one of whose vocations is to influence business incentives. Secondly, we will work to link our research with business accounting. National accounting only has a direct effect on policies. In order to benefit from the performative effects of business accounting, we need to make changes to it similar to those we are aiming for at the macro level. In this way, it would not only be possible to supply the new indicators or accounts with detailed data, but above all to monitor the effects of economic instruments in order to adjust national action. On another note, the environment is essentially an issue that goes beyond the usual management perimeter of companies: climate change is global, ecosystems and species are interconnected, aquatic environments are managed on the scale of catchment basins, and so on. As a result, environmental problems are most often resolved collectively. It is therefore necessary to see how these players can tackle these issues in a coordinated way, and what role the State can play, which has until now been the main instigator of actions in favour of the environment.

¹² "Development that is economically efficient, socially equitable and ecologically sustainable" (Brundtland, 1987).

Thinking about and designing such a micro-macro linkage around environmental accounting has hardly been done until now (Feger and Mermet, 2021a; Ingram et al., 2022) and never according to the principles of strong sustainability. The micro level will refer to the accounting perimeter of organisations, and the macro level to the domain of state action, i.e. the national territory (which is also the perimeter of National accounting). Our research approach is therefore to develop National accounting in order to improve public action from a strong sustainability perspective. This thesis thus has a normative vocation. To this end, we will seek to answer the following question: **why and how can links be made between national ecological debts and organisations?**

We will try to verify the following hypotheses¹³ to answer this general question. The first two relate to 'why' and the last two to 'how':

- H1 - In National accounting, the integration of environmental issues in the form of debts gives new support to environmental players¹⁴ in economic governance.
- H2 - The accounting link between the macro and micro levels strengthens the State's scope for action, and enables economic players to coordinate to manage issues that go beyond their usual perimeter.
- H3 - Conceptually, the proposals for environmental NA can be strengthened from a strong sustainability perspective.
- H4 - Data exists to build them over the medium term while respecting statistical quality constraints.

4. Disciplinary anchoring

This thesis focuses on four areas (financial accounting, national accounting, economics and ecology) that cut across several disciplinary fields: in particular ecological economics, accounting and the sociology of quantification. Each of these fields has contributed its own analytical framework, questions, methods and body of literature.

As this thesis is concerned with the question of the environmental extension of accounting, **ecological economics** logically appears to be an essential anchor. Ecological economics is more a field of research than a discipline in the strict sense. Its roots lie in economics, of course - particularly institutional economics and resource economics - and in scientific ecology, but also in critical sociology and environmental history. (Merino-Saum and Roman, 2012a, p. 4). Its aim is to understand the interdependencies that exist between economic and ecological systems and to make normative proposals to ensure their sustainability. It is these relationships that we will attempt to highlight in the

¹³ Hypotheses to be verified empirically and conceptually. In relation to the writing of the chapters, they are formulated ex post for didactic purposes. In reality, they are the result of a recursive process throughout the thesis which involved phases of abduction, deduction and induction (David et al., 2012, p. 115). The fieldwork, in particular (Chapters 4, 5, 6), enabled them to be reformulated progressively.

¹⁴ In the sense of the strategic analysis of environmental management, such a player is "the initiator [of a change in favour of the environment, i.e. the person who will] push it skilfully and obstinately in the face of other players for whom it is just another concern and therefore often (to use the familiar understatement) not really a priority; it means taking the issue all the way, i.e. until the change has taken place and, all of a sudden, all the players can act as if they had all taken it on". (Mermet and Leménager, 2015, p. 50). Environmental NGOs are not always the answer, which is rather "in this biodiversity issue, at time 't', [...] those who actively carry biodiversity concerns into the strategic interactions between stakeholders" (ib.).

accounts, with a view to managing them in a sustainable way. Merino-Saum and Roman (2012b, p. 4) then adds that a number of principles are regularly found among ecological economists:

"The choice of methodological pluralism, the affirmation of the incommensurability of the values at stake in the relationship between human beings and their environment, the importance of uncertainty, path *dependency* and irreversibility, the ethical need to take account of the interests of future generations, the (very) limited substitutability of natural capital for other forms of capital, and the systems approach.

These elements will serve as guides throughout this work.

Historically, **National accounting (NA)**¹⁵ was built at the interface of accounting, statistics and (Keynesian) economics (Vanoli, 2002, p. 549). Broadly speaking, accounting provides an information structure, but also specific functions (counting, taking into account, reporting and rendering accounts), to which we will return later. Statistics provides measurement methods. Finally, economics provides concepts and, above all, specific questions and interpretation frameworks. Economists, first and foremost Keynes, have highlighted accounting aggregates by focusing their attention on certain ones, proposing explanations for their evolution (joint or otherwise) and linking them to doctrines of action¹⁶.

This thesis is clearly part of the accounting strand of the BA. In a broad sense, **accounting** is "the preparation and framing of information (qualitative and quantitative) to assist specific organisational and decision-making processes" (Jolland 2017, in Feger et al. 2018, p.2). Unlike economics, accounting:

"focuses on the detailed analysis of the roles of information systems in the context of the concrete complexities of organisational management, building on the fundamental concepts of account and *accountability*" (Feger et al., 2018, p. 2)

The aim of this thesis is in line with this. However, in relation to Business accounting, a gap appears when studying National accounting: its aim is less to organise economic life through *accountability* than to "infuse public decision-making or the functioning of democracy". (Timbeau, 2022). But we shall see that the NA's coordinating function is far from non-existent for all that. In terms of method, this thesis falls well within the field of accounting: it will combine theoretical reflections based on other social sciences while formulating analyses of the organisation in concrete cases (Feger et al., 2018). More broadly, management sciences (David et al., 2012) will provide explicit or underlying framing elements, particularly through strategic analysis of environmental management (Mermet, 2011).

The statistical aspect of National accounting is mobilised via the **sociology of quantification** (Desrosières, 2010; Espeland and Stevens, 2008). In fact, this discipline takes a broad view, which at

¹⁵ Although it is intuitively the central discipline of this thesis, we have not fully explored the field of National accounting. We attribute this, perhaps wrongly, to the fact that it is not as well developed as statistics or economics, and that it has been absorbed or dissolved into these two other disciplines since the 1990s-2000s. (Archambault et al., 2001; Vanoli, 2002). The writings we have used are by experts who publish little in academic journals. This literature will be found in the first two chapters.

¹⁶ Today, economists have an ambiguous position on accounting. The development of neoclassical theory has distanced them from it, with the exception of practising economists (advisers to public authorities, analysts, etc.). (Vanoli, 2002, p. 553). On the academic side, the development of purely theoretical approaches, or approaches based on *ad hoc databases*, has often led academics to "forget" that it is accounting concepts that they are using. As a result, these concepts are generally little or not questioned at all, apart from GDP, because of the criticism it can generate ('beyond-GDP' research trend).

times overlaps with the accounting discipline. But Desrosières' sociological work, which we use regularly, is primarily concerned with statistics. For him, "statistical work aims to reduce the multiplicity of situations, and to provide a summarised description that can be remembered and used as a basis for action" (Desrosières, 2010, p. 22). So it seems to us that one of the main functions of statistics is to create 'spaces of equivalence'. Desrosières (2008b, p. 224) explains that:

"Among the schemes for describing reality and acting on it that statistics helps to establish and maintain, one of the most important is that of the space of equivalence, which makes comparisons, calculations and negotiations possible. Such a space is inseparably political and cognitive".

The operations of defining a set, coding, taxonomy, classification and quantification help to create comparability between objects that were not previously placed on the same level. This construction makes it possible to change the way we look at the objects brought together in this way and to open up new management methods. In particular, it creates the possibility of standardising management for the whole, or, on the contrary, of arbitrating between its components. These two actions are, of course, possible outside a formal statistical equivalence space, but history shows that the creation or inclusion of certain objects in a new equivalence space has always resulted in a change in their management (Desrosières, 2010).

This rather sociological starting point has led us to largely leave aside the methodological aspects of statistics and its recent developments. The question of data collection is considered in a fairly traditional way, not addressing the issue of big data for example (for a discussion of the importance of this aspect, see for example: Radermacher, 2020).

5. Thesis plan

This thesis is a classic manuscript which nevertheless contains an article in academic format (chapter 4). The argument is built around six chapters, divided into two parts.

The first part is a critical analysis of existing accounting systems and proposals for environmental extensions. Its aim is to define our working area while analysing economic NA and proposals for environmental NA. The aim is to describe the conditions and constraints for designing an accounting system that can guide public decision-makers towards a sustainable economy.

The first chapter will set out our general position and the potential of National accounting for government action. To this end, we will present the interrelationships that exist between National accounting, the governance of public action and the modes of intervention in the economy throughout history. We will pay closer attention to the uses of national accounting, which will be an opportunity to understand its specificity in relation to other public statistics. Secondly, we will map out the proposals for environmental national accounting. Symmetrically to the first part, we will detail the issues involved in integrating the environment into National accounting from the same two angles: uses and governance. We will see that the academic literature on environmental national accounting is fairly recent on these two subjects, and that some important questions deserve further development.

The second chapter describes the historical and conceptual relationship between business accounting and national accounting. We will see how National accounting was built on the basis of Business accounting, and the translations made in the process under the influence of economists. This chapter

will contribute to the translation of the CARE business accounting model (Rambaud and Richard, 2015) into National accounting. Thus, the most detailed conceptual proposal of ecological debts to date will help to further develop Vanoli's (1995, 2017) proposal in Chapter 5.

The third chapter will look at the history of the controversies surrounding the monetary valuation of biodiversity within the *System of Environmental and Economic Accounting* (SEEA) community (which is the main proposal for environmental national accounts, developed since 1994 under the aegis of the UN). Four sub-controversies will be analysed: the choice of unit of account (monetary or biophysical), the framing of monetary valuation (according to the cost or damage approach), the degree of modelling acceptable for this valuation, and the structure of the accounting sequence. We will see that the SEEA has vacillated between weak and strong sustainability since the 1990s, before finally shifting its monetary accounts towards weak sustainability in 2020. This chapter clarifies this area of controversy, which has caused problems, identifies the procedural and rational causes of their historical evolution and positions us for the rest of the thesis.

The second part of the thesis will present a proposal to extend National accounting to include ecological debts. Throughout the three chapters of this part, we will describe the accounting conventions adopted and their consequences, what data can be mobilised (practically, but also if they are in line with the principles of official statistics), what the potential uses of this accounting are, and finally what micro-macro links are emerging. Case studies will be used to flesh out, refine and put our proposals to the test.

Chapter 4 will introduce the accounting model based on the previous sections. The next two chapters (5 and 6) will present our work on ecological debts for terrestrial biodiversity and aquatic environments based on existing public policy frameworks. In the first case, we will use the European Birds Directive and the Habitats, Fauna and Flora Directive, which define protected species and habitats, in conjunction with impact assessments. The French framework adopted in 2021 to achieve no net land-take is also being used. For aquatic environments, we will be relying on the Water Framework Directive and its French transposition.

We will conclude with a general discussion to address the issues raised. It will extend the reflections by opening them up and identifying avenues for future research.

Part 1- Critical study of existing systems or systems under construction

Chapter 1 - National accounting: current uses and prospects opened up by environmental issues

1. Introduction: the representation-action-governance triptych

Alain Desrosières (2008a, p. 56) has given a rich and convincing description of the connection between certain forms of statistics, modes of economic intervention and what this translates into in terms of thinking about society and the place that the State gives itself in the economy (Table 1). He defines five forms of state that have emerged progressively throughout history: engineering, liberal, welfare, Keynesian and neo-liberal. These forms coexist and are sometimes added to one another, but it can be seen that some dominate in different historical periods, depending on the country.

Table 1 Five typical configurations of the state's role in steering the economy (Desrosières, 2008a, p. 56)

The State, the Market and Statistics

	Way of thinking about society and the economy	Mode of action	Forms of statistics
Engineering state Production and people (since the 17th century)	Hierarchical and rationally organised institution France from Colbert to de Gaulle USSR	Optimisation under constraint. Cost reduction. Centralized planning. Technocracy. Major works. Long-term vision.	Demography. Production in physical quantities. Inter-industry purchasing tables. Material balances (USSR)
Liberal state Trade and prices (since the 18th century)	Physiocracy A large market. Free competition.	Fight against corporatism. Free trade. Anti-trust laws protecting competition.	Statistics promoting market transparency (case of US agriculture). Measures of possible dominant positions. Market shares.
Welfare state Wage labour and its protection (since the end of the 19th century)	The labour market is not a market like any other. It must be protected.	Laws on working hours, accidents, unemployment, pensions. Compulsory insurance systems guaranteeing social rights.	Labour statistics. Wages, employment, unemployment. Sample surveys of workers' budgets. Measures of social inequality. Consumer price indices.
Keynesian state Aggregate demand and its components (since the 1940s)	The market cannot function on its own without generating crises. It must be regulated at the global level.	Monitoring and steering of the possible gap between aggregate supply and demand via monetary and fiscal policies.	National accounting. Analysis of the economic situation. Economic budgets.
Neo-liberal state Polycentrism, incentives, ranking (since the 1990s)	One big market. Free and undistorted competition. Financialisation. Multiplication of decision-making centres in the form of networks.	Shift from rights to incentives. Examples: bonus-malus. Market for pollution rights. Transformation of administrations into agencies. Contractualisation. Coordination by emulation. Example of the European Open Method of Coordination.	Objectification of new equivalence spaces. Objectification of the contractual qualities of statistics. Construction and use of benchmarking indicators to evaluate and rank performance. Benchmarking complements or replaces directives and regulations. Statistics in financial markets. Controversies over the quantification of GDP.

The conceptual framework we are going to use for this thesis is largely based on this categorisation. We retain the idea of modes of action and forms of statistics. But we reinterpret the first column by separating out three aspects which seem to us to be somewhat mixed up in the 'way of thinking about society and the economy': governance (which sheds more direct light on the actors), the scales of the individual and the whole economy (or micro and macro), and what we call the theoretical perspective (or factor). This last point corresponds to a more general conception of the economy, whether explanatory or normative. This distinction makes it easier to isolate the issues to be addressed when analysing and designing accounts.

This is how we can move from the Desrosières table to Figure 1. Public action takes shape in a certain "governance", it is based on a "representation of the field of action" and is broken down into "modes of action", or instruments of intervention, in the economy and society. These poles are linked to real objects and institutions. A particularity of our thesis subject is that there are two scales for these objects: at national level, these are State administrations and democratic institutions, National

accounting and a set of public policy instruments (Halpern et al., 2004). (Halpern et al., 2014; Lascoumes and Le Galès, 2004). At company level, there is also specific governance, financial accounting and a business model.

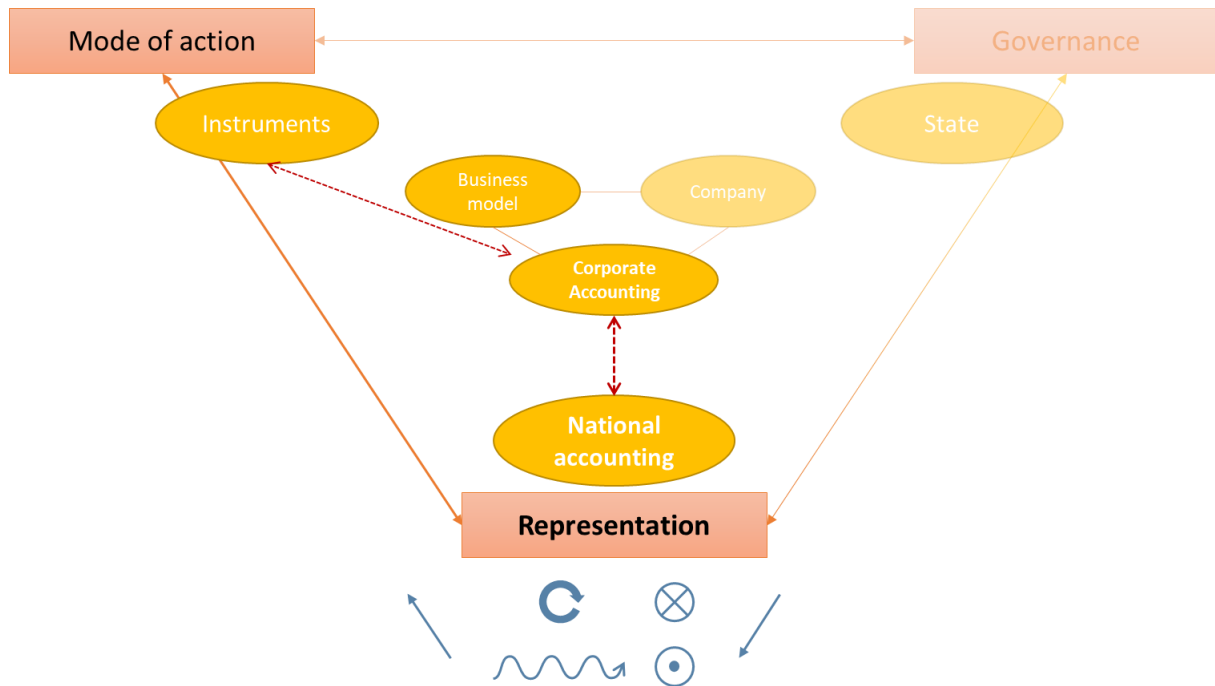


Figure 1 Triptych linking accounting representation, modes of action and governance

Legend: the blue pictograms represent the different factors that determine accounting policies: the arrow on the left for the "usage" factor, the thick arrow that closes in on itself for the "accounting constraint", the zigzag arrow for the "historical factors", the cross in the circle (arrow seen from behind) for the "theoretical factors", the dot in the circle (arrow pointing towards the reader) for the "methodological" factors and the arrow on the right for the governance factors.

The key hypothesis, which we have taken from work in the sociology of quantification (Desrosières, 2010, 2008a, 2008b; Espeland and Stevens, 2008) and critical accounting (for summaries, see Feger, 2016 ; Feger et al., 2018) is as follows: these three poles are linked and there is a back-and-forth between them in the form of more or less strong feedback. Each pole constitutes a space of possibilities and constraints for the other two. We could even go so far as to say that it is not possible to think of one pole independently of the other.

This is particularly true for National accounting. As far as business accounting is concerned, this is more true for management accounting than for balance sheet accounting. Management accounting offers more possibilities and is for internal use, which disconnects it from the influence of stakeholders; on the other hand, balance sheet accounting is standardised by the state, which introduces strong constraints (Colasse and Standish, 1998; Richard et al., 2018).

To understand this interconnection, we need to start by realising that national accounting, like any accounting system (and this is also partly true of indicators), is a fairly complex assembly of different building blocks. Each of them can be modelled in a number of ways, although the possibilities are not infinite. For example, corporate balance sheet accounting and national accounting offer far fewer possibilities than management accounting and economic modelling. The first two are standardised, and therefore stabilised and harmonised (in charts of accounts or international standards for companies; and in the System of national accounts drawn up under the aegis of the UN). Management

accounting and economic modelling, on the other hand, are constructed much more freely to answer specific questions posed by a company itself, for its own internal use, or by economists (researchers, practitioners, etc.) for a given research project.

The accounting bricks that can be modulated are as follows:

- accounting structure (type of accounts present or absent: income and expenditure alone or with assets; delimitation of accounts; their relationships),
- the quantification method (unit of account; monetary valuation at market price or historical cost),
- what is included or excluded (public services and military goods were included late; the environment is still largely absent),
- the place given to certain objects or situations (R&D expenditure has gone from being a simple recurrent expenditure to a store of value)
- or the formatting of published tables.

These choices are not neutral in that they convey a certain conception, often implicit, of the relationships between those who draw up the accounts, those who keep them and a set of stakeholders (these are the **factors linked to the governance** of the BA, in Figure 1). Upstream, the conceptual choices are made by some players and not others. Various levels of participation and deliberation may come into play, which greatly influences design choices (Jany-Catrice and Pinaud, 2017). Downstream, accounting can be seen as a language that makes it possible to make oneself understood and to translate one's own issues into terms that are intelligible to all. If objects (such as the environment, for example) have no translation in this language, no words to describe them, it is not possible to forge links with the other issues already present and managed with this accounting system (Espeland and Stevens, 2008).

On another level, the design choices made for an accounting system also reflect a certain vision of the type of action it is intended to support (**factors linked to modes of action**). For example, whether or not to show certain items is linked to the choice of whether or not to manage them. As another example, a historical cost valuation is linked to the need to preserve the capital provided, whereas a net present value valuation is intended to inform investment choices. (Richard, 2015). Different levels of analysis can be distinguished: whether or not certain accounting functions are mobilised (Stolowy et al., 2010The National accounting functions are described in section 2.4); the method of intervention chosen (e.g. monetary, fiscal or budgetary policy, regulation); the policy area targeted (innovation, competitiveness, health, environment, equity, etc.); or the target of the action (a macroeconomic indicator or aggregate, such as inflation or the growth rate, or individual behaviour). A key concept linked to this perspective is that of *usage*, which is placed between the accounting representation and the action itself (double orange arrow linking these two poles in Figure 1). We will take a closer look at this concept in this chapter.

Since accounting is a management tool, we believe that factors relating to governance and modes of action best explain the conventions adopted. Vanoli (2002, p. 111) first mentions "public policy priorities", which correspond to the two factors described above. The beginnings of national accounts construction in the 1940s and 1950s, with harmonisation still in its infancy, make it possible to identify other factors that played a role in stabilising the conventions adopted by different countries.

The statistical sources available obviously have a role to play¹⁷. We slightly rename this aspect "**methodological factors**", which also includes certain institutional considerations about the approvals that are put in place to obtain the data, the degree of modelling accepted, etc.

The '**theoretical factors**' can be drawn from a number of disciplines: mainly economics, particularly the Keynesian branch, but also political science. Desrosières' "ways of thinking about society and the economy" give substance to such theoretical considerations. The aim is to draw up very general programmes that are consistent with a certain body of knowledge about how the objects to be managed work.

Historical factors" regularly come into play. The name of these factors may seem inaccurate, but it is intended to bring together what appears to be contingent in the gradual construction of an accounting system. We are thinking, for example, of the inherited organisation of administrations, which can generate inertia or specifically national cultures; of the particular trajectories of individuals; and of the more or less significant exchanges of knowledge between countries.

Finally, we add a last type of factor, which Vanoli does not mention, but which we separate from the previous one: the "**accounting constraint**". This is a salient aspect when it comes to modifying National accounting. It corresponds to the set of principles accumulated in accounting standards that must be taken into account to guarantee overall consistency. This constraint is partly based on accounting theory, which stems from the academic discipline of the same name. In the case of the NA, however, it has taken on a particular hue (as we shall see in Chapter 2).

Nevertheless, it seems to us that the question of public policy priorities remains the main one, even if it does not necessarily come from "politicians". In fact, economic and accounting theories conceal normative agendas and political influences that are often clear, despite the veneer of neutrality and objectivity sometimes maintained by their authors. These proposals are more or less well adapted to the context that guides public policy, hence their successes and failures depending on the period. The obstacles linked to sources and institutional considerations seem to us to be important in the short term, but do not hold up in the face of a sufficiently marked context (a period of crisis, a renewal of State action). Administrations are being reorganised, surveys are being set up, and data is being reused or temporarily modelled. The question of individual trajectories is a special one: history often points to strong or charismatic personalities as key factors in the success of an initiative (Tinbergen in the Netherlands, Monnet and Gruson in France, Keynes and Stone in the UK and internationally). Does this mean that nothing would have happened without them? We can imagine that political factors or general advances in knowledge call for the expression of this type of personality, and that there is always at least one who will respond. Once again, we can make the hypothesis that their appearance is above all a question that saves or loses time for a country or an administration, but that it is not a blocking factor in the long term.

The link between the national and individual (or macro and micro) levels varies from one centre and country to another. The French NA is probably the one that has forged the most conceptual links with

¹⁷ Vanoli indicates that the impetus of statistical sources played a role at the outset, which he describes. For example, the income approach, to which final expenditure is gradually being added (more prevalent in the United States, Canada and the United Kingdom), takes second place to the detailed description of the production system in the Scandinavian countries, the Netherlands and France. Information on incomes is scarce or considered unreliable, while, following the war, data on the distribution of raw materials is fine and robust (Vanoli, 2002, p. 111). Although a determining factor, it seems to us that this factor remains linked to user impulses.

business accounting and is the most directly supplied with business accounting data throughout the world¹⁸. State instruments can have a direct connection with individuals and organisations (legislative and regulatory instruments, taxation, public spending), or indirectly, by influencing their relationships or their environment (monetary policies, for example). Similarly, state and private organisations sometimes have governance links, particularly when the state has holdings in companies, or when representatives of private players take part - particularly in the form of lobbying - in democratic debates and in the drafting of laws. This thesis will provide a broad description of the connection between the different levels of accounting (chapter 2) and will analyse in part the instruments that exist or are to be created, linking the micro and macro levels, to manage the environment.

The elements most discussed in this thesis are the 'representation' aspect, and in particular the connection between Business accounting and National accounting. Then there is the question of modes of action, with a pre-eminence of public instruments and their influence on business models, and therefore on impacts (positive and negative) on the environment. Finally, the idea of governance plays a more secondary role. It is discussed in terms of the role of designers and the creation of a common language enabling certain stakeholders to be included or excluded from management.

The purpose of this chapter is to illustrate this triptych and to introduce the specific features of national accounting compared with other tools such as business accounting, official statistics or isolated indicators. We will draw on the history of National accounting to understand how the design choices made in different countries and over the course of history are linked to specific forms of public governance and methods of intervention in the economy. We will focus on the recent period, which will serve as the starting point for our work. The aim is to provide an overview of the triptych, which will necessarily be partial, but will focus on National accounting.

This will give us an idea of what we can expect from a (re)conception of such accounting to include the environment. Does it have the potential to modify or reinforce existing environmental policies, or even open up the possibility of new modes of state intervention to manage environmental problems? What are the possible impacts of such changes on the governance of environmental and economic policies?

Initially, we will focus on economic national accounting and describe how it has developed in relation to particular forms of governance and action. This historical overview will enable us to conclude with the specific features of national accounting and how these different accounting functions (counting, recording in accounts, reporting and submitting accounts)¹⁹ have been mobilised.

Following the study of the institute (economic), we will look at the environment in a second part. Numerous proposals for environmental statistics and accounting have emerged, mainly since the 1990s. We will propose a cartography to guide us in this field. All these proposals have been developed with the ambition of contributing to an improvement in the state of the environment. But how do their designers imagine change will come about? Is this question even being addressed? This will be the subject of the next sub-section. Finally, we will briefly describe the connection between these accounting proposals (in particular the SEEA, which is the most developed) and the associated public policies. All this will enable us to describe our research position on these different aspects and the lines of work for this thesis.

¹⁸ Malaysia also makes extensive use of these data, while other countries tend to use surveys based on accounting concepts and tax data. (United Nations, 2000).

¹⁹ (Stolowy et al., 2010)

2. Statistics and the State: specific features and uses of National accounting (NA)

2.1. An intermediate position between raw data and indicators

If we look at the level of aggregation or detail of the National accounting (NA) compared with other types of quantification tools, we quickly see that the NA has an intermediate place in the pyramid of information systems. It lies between raw data on the one hand, and synthetic indicators that reduce complexity to a very limited set of information on the other (Figure 2; Radermacher, 2020). Raw data and NA have a variety of uses, while indicators are much more specific. At the centre, the NA provides a detailed but simplified view of reality.

Thus, NA does not have the same relationship as indicators or raw data with other fields such as science (economics) or politics (Figure 2; Radermacher, 2020). Being a fairly technical subject, with its own vocabulary, accounting is rarely discussed publicly and is more in the domain of expertise. It has a privileged relationship with economic models, which make it possible to explain and interpret NA figures, or to project them according to scenarios. For Radermacher (2020, pp. 94-95) NA is a key element in the formation of technical judgements on the state of the economy, which can feed into discussions on the public policies to be implemented.

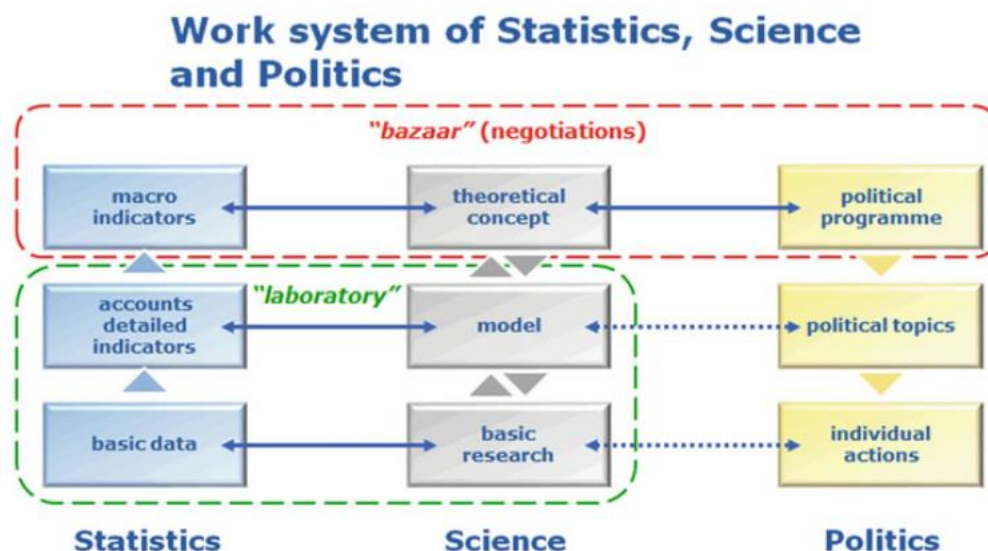


Figure 2 Co-construction of information systems, scientific knowledge and policies (Radermacher, 2020)

Contrary to what is suggested by Figure 2 there is a link between the political and statistical aspects. It is not essential to go through the "scientific" translation. Statistics provide information on current and past events, and their structure is less open to criticism than models, providing a more solid basis for discussion. Another point to clarify is the separation between these three areas. Figure 2 effectively distinguishes between what is theory (the "science" column in Figure 2), representation ("statistics" column), governance and the choice of actions to be taken ("politics" column). But it should not be forgotten that the whole enterprise is fundamentally political. As the sociology of science and statistics has repeatedly shown (Desrosières, 2008a; Espeland and Stevens, 2008; Miller, 1986). The fact remains that the groups of people and the discussions in Radermacher's 'bazaar' and 'laboratory' are quite different in nature and are not guided by the same principles. The distinction therefore seems valid to us. Thus, for Radermacher:

"It is the task of the actors in the laboratory, to reduce the complexity as far as is possible with the technical and methodical tools at their disposal. However, the (pre-)selection of relevant aspects, or the setting of indicator-related targets, or the definition of weighting schemes (as part of composite indicators and rankings) may then, at least to a large extent, belong to the field of politics, i.e. the 'bazaar'." (Radermacher, 2020, p. 95)

It should also be noted that the NA, unlike the indicators and a large number of statistics, only covers certain areas of community life. Today, the NA focuses mainly on the economy. However, some areas of government action do not involve it, or involve it very little: criminal law, informational incentives (communication campaigns aimed at the general public), education or sports policies, for example. These modes of action sometimes use a large number of statistics, which justifies the creation of an *ad hoc* department within the ministries concerned (in France), but they do not a priori rely on accounting.

Health policy is a special field of public action. As this policy is largely based on a system of cost sharing and redistribution, there have been periods when health satellite accounts have existed. This raises the question of how close these issues are to economic ones, to the point of considering accounting connections. Other related fields also lend themselves to this, leading to the creation of such satellite accounts (Vanoli, 2002, pp. 257-258). For example, for the environment or Households' domestic work²⁰.

We will return to the specifics of NA at the end of this section. Before that, let's look at the governance of NA production and the historical uses to which it has been put.

2.2.NA governance: who keeps the accounts and for whom?

The players involved in the "governance-mode of action-representation" triptych are diverse. Their roles can be mapped out according to whether they are designers, producers, users, implementers or decision-makers (Figure 3). At the heart of the interactions between these players is the definition of objectives relating to the management of a problem.

The intuitive separation between decision-makers and implementers in fact conceals a pyramid of players and decisions ranging from broad to specific issues. This can be seen very clearly, for example, in ministerial organisation charts, the structure of which is a fairly accurate reflection of the way in which problems are to be managed. In post-war France, a central institution in the reconstruction of intervention in the economy was the Commissariat général au Plan (CGP), created by Jean Monnet in 1946. It was a consultative body that guided macroeconomic and business decisions. Today, the Ministry of the Economy and Finance is at the heart of economic policy.

²⁰ The other satellite accounts created in France include the most important: agriculture, services, trade, forestry and tourism. However, their rationale is not to connect relatively new or disjointed areas of the economy, but to detail elements masked by the conventions of the central National accounting framework (to give more detail).

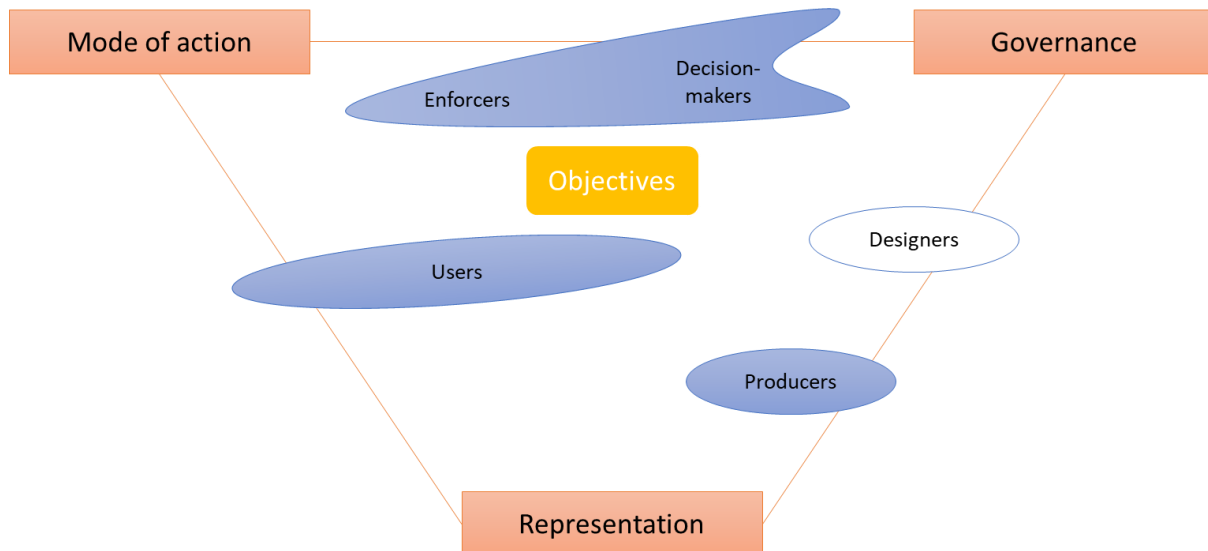


Figure 3 Typical players involved with NA

On the contrary, the separation between accounting designers, users and producers that we see today is less continuous. Historically, however, the roles were closely linked in departments with a small staff. They were familiar with, and sometimes even acted on, the entire chain of action at the highest decision-making level, while at the same time designing and producing the accounts. In France, this was the role of the *Service des Etudes Économiques et Financières* (SEEF) at the Ministry of Finance in 1950. Headed by François Gruson, this department drew up the first national accounts within the Ministry, an executive administration at the service of the Minister. Before joining the Ministry of Finance, part of Gruson's team worked briefly at the CGP. Academic research provided a perspective and proposals on their respective work (Fourquet, 1980; Miller, 1986; Terray, 2003). The development of a genuine economic language to bring these players together is described by Desrosières (2008b, pp. 61-78).

With the extension of the quantification of social phenomena and the strengthening of the associated methods, a movement towards the autonomy of statistics ("producers") took place throughout the world after the Second World War. Initially produced in 'offices', statistics were then produced in 'institutes', a term that suggests the more scientific nature of the work carried out, or 'offices', more distant from the administration (Desrosières, 2008a, p. 31). This greater independence of statistics was reinforced later in France than elsewhere, but National accounting and the SEEF did not escape this trend. They were merged into the *Institut national de la statistique et de l'information économique* (INSEE) in 1962, which itself became increasingly autonomous over the decades.

The institutional separation between the so-called 'producer' and 'user' departments - which use figures on a relatively routine basis or as a complement to more ad hoc data collection - has largely removed from the landscape the discussion of accounting design choices in relation to doctrines of action.

On the one hand, unlike the concept of decision-maker, the notion of user does not really convey the idea of setting objectives and choosing methods of action. On the other hand, it is more reassuring, because the implicitly "political" concept of decision-maker can be associated with the idea of fickleness, short-termism and even clientelism.

On the other hand, conventions, which are often considered too technical, are now discussed by producers, with little involvement of "users" (not even "decision-makers"). In France, however, the

Commission Nationale de l'Information Statistique (CNIS) was set up to maintain a link with users. International standardisation processes, both at European level (creating the European System of Accounts) and worldwide, under the aegis of the UN (producing the System of National Accounts, due for revision in 2025), seem to involve even fewer users, who are replaced by 'experts', often from statistical institutes or international organisations.

Today, it is difficult to identify a group of true designers, bringing together producers, decision-makers and theorists. Even in the field of environmental NA, which is particularly innovative, politicians are absent, users are peripheral and the academic theorists or high-level national accountants who were present in the 1990s have almost completely disappeared from the landscape (see chapter 3). NA (but this is also true of business accounting) is no longer discussed by political decision-makers, or even by senior civil servants who are not involved in its production. Persistent criticisms, already perceived by the designers of National accounting in the 40s and 50s, return to the front of the stage more or less regularly, but do not lead to sufficient questioning for the decision-making spheres to regain control of the design of this tool.

Let's now look in more detail at the "users" section, which will interest us as the first means of creating usable accounts (Figure 4). We can already make a distinction in principle between academic economists, who use statistics and NA as data to understand, from a positive perspective, how the economy works, and the sphere of action, which brings together a group of players who make more or less formal and institutionalised use of these data.

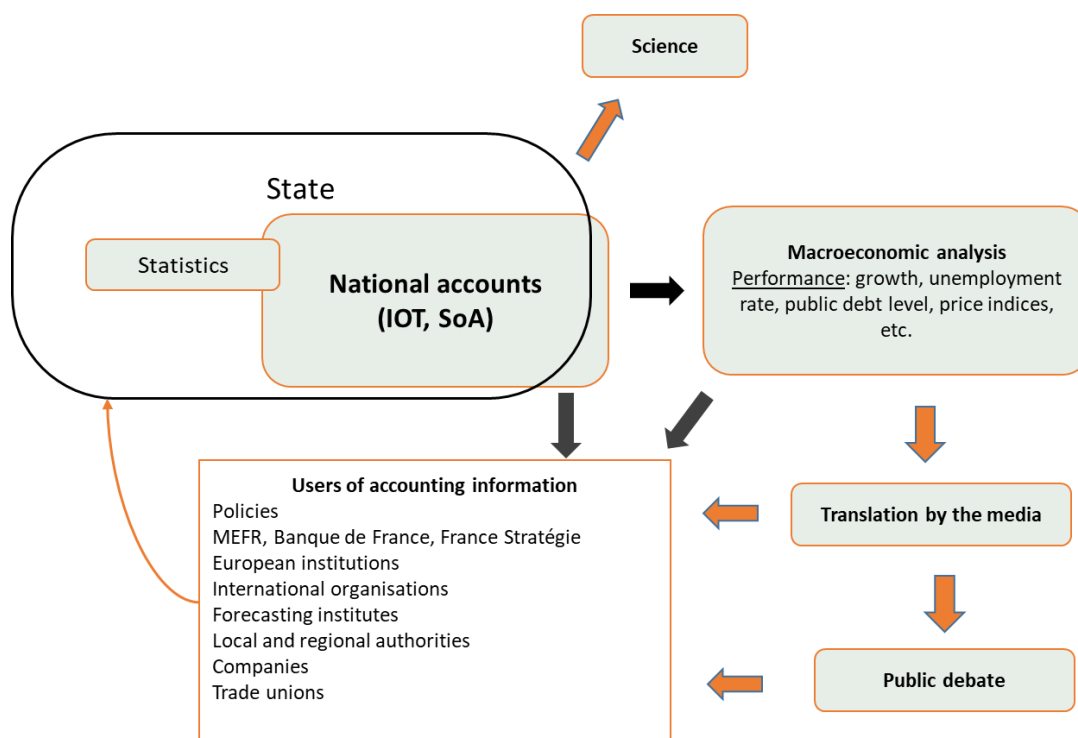


Figure 4 Mobilisation of accounting information by users.

Source: author, based on (Rambaud, 2020). Black arrows: institutionalised channels, orange arrows: informal channels. Top of diagram: used as a proof tool, bottom of diagram: used as a government tool. IOT: Input-output tables; SOA: Sequence of accounts. MEFR: Ministry of the Economy, Finance and Recovery.

Government departments and their satellites (consultant economists, who rely on the normative branch of economics, think tanks, forecasting institutes, etc.) are among the most important users of NA. This category also includes international bodies that use the NA as a basis for allocating subsidies

or estimating budget contributions. The media convey the performance of the economy (growth and unemployment rates, public debt, inflation, etc.) to citizens by selecting the dimensions that interest or affect them most. As the State is partly responsible for the state of the economy, it provides a kind of accountability to the public by publishing these National accounting²¹. In this way, at the end of their mandate, citizens can decide on the quality of the management carried out by their representatives.

Then there are the less regular users, at least today. Trade unions and companies were stakeholders in the Commissariat général au Plan, which made them major users at the time. Today, these groups mobilise the NA individually and occasionally, according to their own needs. An archetypal example is the use of NA by large companies and financial players to find their way around their industries or to compare industries or countries in which to invest; trade unions are more interested in the question of the distribution of value added.

We have presented what we consider to be the main players involved in National accounting to illustrate the governance part of our triptych. We will now go into detail about the historical uses of the NA, up to the recent period.

2.3. The uses of the NA as a tool of government determine its characteristics

In this section, we will give some historical examples showing how National accounting was built in close connection with specific conceptions of action. We will try to cite a certain diversity of accounting "bricks" to illustrate that, from the major design choices to the details, models of action are always present.

2.3.1. Elements of definition

We begin by setting out the elements of a method for analysing the uses of an information system. Initially defined for a detailed analysis of the current uses of the NA and the potential uses of the environmental NA (which could not be fully achieved), we will use these points of method as a basis for reflection and we will try to get as close as possible to them. Given the sources available, this will not always be possible.

The notion of use is defined as follows: the mobilisation of accounting information by an actor for a specific purpose. This raises the questions: who uses what and for what purpose? This opens up a wide range of *a priori* situations, which we propose to restrict in order to remain within the context of the NA.

The information we are interested in here is that contained in the National accounting system. It includes accounts (the basic unit of classification), balances (resulting from transactions between accounts) and the underlying raw data. Economic statistics are very diverse; we will leave aside what is not involved in the NA.

²¹ In reality, the State accounts for its actions through a variety of means (political speeches, public policy evaluations, parliamentary reports, etc.). Among the accounting tools, it could rightly be said that the State's accounting, which records its tax revenues and expenditure, is a more direct means of accounting for its actions. National accounting, as a representation of the economy, comes into play all the same, because the State is certainly the actor that has the most control over national economic destiny, even if this power is largely weakened in liberal democracies (Pottier, 2018).

The traditional users of the NA are the national administrations in charge of the State budget, tax collection, forecasting, financial stability and the general direction of economic policy. Democratic institutions (Parliament in particular) have an overview of all these elements and contribute to decision-making. International institutions are a third type of player, mobilising national economic information. Finally, forecasting and research institutes also use economic data in their work.

The mobilisation of information is also relatively diverse. A distinction can be made between the translation, analysis and interpretation of accounting information on the one hand, and its direct use for action on the other. The former includes comparing the accounting value with other numbers in the same accounts (integrated analysis), with past values (construction of time series), or with external numbers or qualitative elements (for example in cost-benefit analyses); calculating summary indicators (differences between several accounts, analysis ratios); calibrating a model, copying the accounting number as an input parameter for a model, projections (estimates of changes in a value in the future). These translations can then be used in decision-making and action frameworks.

Accounting values can also be used directly to take action, without any prior translation. Here we find 1) the copying of figures in reports or their recurrent verbal use or structuring of discussions for which a certain scope can be defined (e.g. parliamentary debates, interministerial meetings, arbitration by ministerial departments); 2) the direct indexation of actions on accounting values (e.g. calculation of budget contributions on the basis of a level of income) or 3) the use of orders of magnitude to calibrate actions (e.g. to estimate an average tax rate, or the level of public spending in a particular area).

To qualify a use, it must be possible to identify a purpose, particularly in terms of someone's action (the person using the information, or another person influenced by the use made of it). The notion of purpose excludes the mere transformation of information with a view to delivering it to a user. This excludes users such as statistical bodies.

So, to analyse usage, we need to find the players who have relatively routine procedures for using figures. This seems to us to be the most tangible way of understanding the notion of 'need' or usage. Each time, we need to ask ourselves the following questions:

- Who is it?
- What information (what accounts, what format)?
- Which information mobilisation procedure (comparison, model input, public policy scenario, etc.)?
- For what purpose, and by whom?

Let's move on to the uses of NA.

2.3.2. Usage as a historical determinant of accounting structure

The historical legacy of the NA is an essential point to describe in order to understand what it is today. In this way, we will try to sketch out the important interconnection between the "mode of action" and "representation" dimensions, and thus, in a nutshell, an important part of the political dimension of NA. The historical contexts and the main users of NA shed light on the choice of conventions adopted.

An article by Bos (2017) and the history of NA by Vanoli (2002) provide us with the historical landmarks that make up the classic historiography of NA on a global scale. We add the statistical dimension, provided by Desrosières, and attempt to highlight the distinct contributions of the three origins of the NA (economics, statistics and accounting), which Bos and Vanoli do not do completely, or only in filigree.

2.3.2.1. *The beginnings: estimating national power and unifying statistics*

Although this may seem to contradict the argument of this section, it is clear that the first statistical works and estimates of national income between the XVII^e and XIX^e centuries were not commissioned by users or rulers, but rather by thinkers, whose success varied according to the period: their work was sometimes used, but often neglected, hidden or rejected more or less strongly depending on their conclusions. The author suffered the same fate, sometimes even exile (Bos, 2017; Desrosières, 2010; Vanoli, 2002). All the same, these pioneers often had reform projects in mind that clearly guided their work, if only in terms of the choice of subjects on which they worked.

Statistics, as the root of National accounting, was born in the context of the unification of territories and societies, and contributed to it in return (Desrosières, 2010). It creates new areas of equivalence, whether territorial (national areas), personal (society) or object (economic), by bringing together under common concepts units that were previously conceived as unique, specific or non-comparable. The German *Statistik* of the XVII^e century, which gave its name to modern methods (although at the time it was exclusively literary), was the first to express "*a synthetic ambition for an overall understanding of a human community (State, region, later city or profession) seen as a whole, endowed with a singular power, and which can only be described by the articulation of numerous traits*". (Desrosières, 2010, p. 29). These features are rigorously classified in order to be comparable. It therefore adopts a holistic stance. This resulted in detailed monographs of the different regions and cities, which, taken together, gave an idea of the whole. It was in France, between 1789 and 1815, that the creation of equivalence areas was most rapid, transformative and covering a large number of fields:

These included "the metric system and the unification of weights and measures (the same everywhere and logically linked together around the metre), the generalisation of the French language and the reduction of patois (through the army and schools), and the universalisation of human rights ("men are born and remain free and equal"), the abolition of nobility privileges and trade guilds, the Civil Code (inspired by the *natural rights* of man in general, and not linked to a particular society), the administrative division of the nation's territory (made homogeneous by the abolition of rights specific to certain provinces) into *departments*, organised identically and of comparable size". (Desrosières, 2010, p. 44).

These new classifications, metrics and coding (fundamental constructs of modern statistics) not only ensured fairness between people and accuracy in the calibration of objects, they also gradually erased local particularities. Because they are applied across an entire territory, they unify it through homogenisation.

It was not until much later, in the first half of the twentieth century, with Kuznets and Clark, that these incipient statistics, whether literary or laying the taxonomic foundations, were linked to national income. ^e(Desrosières, 2010, p. 343).

Between 1660 and 1915, we can see that nascent efforts to estimate a national income had a variety of objectives. The earliest works sought to "*compare the economic strength of England, France and Holland*" or "*assess the potential yield of proposed tax reforms*", while specifying how to raise taxes efficiently and fairly. It could also involve checking the balance of public finances (Vanoli, 2019a, p. 16). Quesnay (in 1760 in France) and Mekerlamp (in 1804 in the Netherlands) went beyond a simple aggregation of income. Quesnay tries to see what 'role in the organisation or disorganisation [of the

economy] the government brings', while Mekerlamp wants to know how the state 'interferes' with trade or economic life in general (Bos, 2017).

This work was not carried out at the request of governments. It was not until the nineteenth century^e that it became a task for the state, firstly in Scandinavia and North America (Bos, 2017). These dynamics are always stimulated by periods of war, poverty or economic decline (ib.).

Prior to its integration into a formal accounting framework (which took place in the 1930s), the concept of income was already linked to various notions (Bos, 2017) production, expenditure (King), population size, wealth, imports and exports, debts, numbers of soldiers and warships (Mekerlamp), wages, taxes, investments (Quesnay, Vauban, King, Merkerlamp), but rarely in an integrated framework, and never all together. Another point is that the notion of production was discussed theoretically (and applied in estimates), and underwent changes: while the early work of King, Petty and Davenant adopted a broad definition that included goods and services, the physiocrats (Quesnay and then Smith) retained only goods.

It was not until the first half of the 20th century^e that this work responded to specific requests from governments that were beginning to take an interventionist stance.

2.3.2.2. Birth of both a doctrine for action (Keynesianism) and a tool for representation

Let's open this section with an enlightening diversions. The concept of unemployment and the creation of the welfare state arose in the wake of the crisis of the 1880s, against a backdrop of legal, statistical and societal developments that shifted the focus from what was previously known as poverty to the concept of the unemployed, and then unemployment (Desrosières, 2010, 2008a, pp. 49-51; Gautié, 2002; Salais et al., 1999). Several changes have made this possible. Firstly, the creation of salaried employment in the law opens up the possibility of linking income and lasting employment, whereas previously work was paid by the day or by the hour. Secondly, the replacement of exhaustive censuses by probabilistic surveys partly removes the moral and individual connotations of poverty and allows the creation of a national variable that globalises the problem. Finally, the retreat of paternalistic capitalism in favour of a greater role for the State led the latter to take charge of this new unemployment. The combination of these factors leads to insurance policies that should help individuals to achieve full employment.

Let's return to National accounting. A very similar movement, which emerged following the crisis of the 1930s, gave rise to Keynesianism, which articulates aggregate supply and demand in a macroeconomic equilibrium. This time, it is a theoretical impulse that is clearly perceptible, mixed with new doctrines of intervention in the economy²²(Keynes, 1936) and statistical tools that were becoming fundamental. The state was then allowed to intervene in the economy to steer this equilibrium while respecting the market economy. With the abandonment of the gold standard in the 1930s (the value of a currency had previously been indexed to that of gold), monetary policy was linked to national income to avoid excessive inflation (Bos, 2017). Keynes also advocated intervening through fiscal policy

²² These two influences were also particularly noticeable in the USSR and its satellites at the same time. At that time, they opted for a strictly physical accountingsystem, which stemmed from a rejection of the market in a particularly advanced engineering-state perspective (Desrosières, 2008a, pp. 41-44).

On a different note, it should also be noted that, in a more subtle way, Keynesian and classical theories (soon to be neoclassical) direct choices towards valuation either at factor costs or at market prices, or towards GDP rather than GNP (Vanoli, 2002, p. 113)..

to achieve a desirable market equilibrium, which markets could not do on their own due to the slow adjustment of prices (particularly wages) (Keynes, 1936).

This doctrine was made possible by recent developments in National accounting. In the United States, the work on national income by Kuznets, in particular, and the beginnings of a debate on the accounting approach to national statistics, were decisive factors in the international standardisation of national income statistics in the decade following the crisis of 1929. The crisis itself was the driving force behind this process (Vanoli, 2002, p. 36). The essential innovation that truly characterises the beginnings of an accounting approach is the creation of aggregates representing the major economic flows in a coherent and balanced framework.

2.3.2.3. Economic management of the war

At the start of the Second World War, the objectives of the NA were to measure macroeconomic variables in order to prepare global policies for a war that we knew was going to be long and total (Vanoli, 2019a, p. 18). In England, the work of Colin Clark, John M. Keynes, James Meade and Richard Stone was guided by the needs of the war. Keynes published an initial series of articles entitled "*How to pay for the war*" in 1940, before becoming the driving force behind the inclusion of National accounting estimates in the budget documents discussed in Parliament (Vries et al., 1993, p. 41). The emphasis was placed on data relating to the revenues needed to finance the war. Nazi Germany, for its part, developed an authoritarian planning system for waging war (Vanoli, 2002; Vries et al., 1993) while Vichy France built up a highly detailed system of industrial statistics (Fourquet, 1980). In Norway, estimates of national income were made under the impetus of the theoreticians Ragnar Frisch and Odd Aukrust, while work on the deterioration of capital stocks linked to the war was carried out by government departments. These were then used to demand compensation from Germany (Vries et al., 1993, p. 49). It can therefore be seen that the work carried out during this period was driven by specific needs (future uses).

In the post-war period, two trends came together to place a strong emphasis on the accounting dimension of NA. The first, which lasted until the 1980s, was the need to rebuild the countries affected by the Second World War; the second, which continues to this day, is the internationalisation of economic policies linked to competition between countries and the increase in development aid.

2.3.2.4. The gradual systematisation of NA in a context of reconstruction

In the aftermath of the Second World War, the need to rebuild Europe and catch up with the United States put the objective of production growth at the forefront. At the same time, inflation was brought under control to avoid its impact on the economy. These choices put production at the centre of the NA, which is still under construction (Vanoli, 2019a, p. 37). The scale of the economic work to be carried out calls for strong regulation, and even a degree of dirigisme in Western countries. The large number of players involved, and therefore the amount of information to be organised, called for a detailed information system on national activity. The Netherlands and France are the two countries that have implemented particularly sophisticated planning, halfway between the two extremes of liberalism and the Soviet system. At the time, data was extremely incomplete, despite the legacy of a functional statistical system following the war.

Desrosières (2008b, pp. 143-176) admirably compares the French and Dutch plans of this period. Despite their similar institutional constructs, he shows that there are significant technical differences,

which are probably linked, among other reasons, to the intellectual training of the people behind the NA: Tinbergen is an academic, while the French national accountants are senior civil servants at the heart of the State. Both plans are resolutely Keynesian in their approach. On the other hand, the tools of representation used, the underlying conception of the economy and the governance of the plans add a slightly more liberal tinge to the Dutch version and a more 'State-engineer' tinge to the French version. Thus, in the latter country, because civil servants have a more practical background, the NA constructed aims to mimic the (imagined) behaviour of price construction by trial and error, which is reflected in the joint construction of past, present and future accounts. This makes it possible to draw a picture of an economy specific to one year. In the Netherlands, on the other hand, Tinbergen is more outside the administration and operates in an academic environment. So the economy, although again conceived as a kind of big business, appears to have a more self-contained, endogenous dynamic. This is what led him to create econometric models to monitor and project changes in aggregates over time. It is this more external, independent and modelled estimate that serves as the basis for the discussion. It is also this vision that explains the much weaker link with business accounting.

In France in the 1950s, the measurement of major aggregates and their interrelationships was less important than a detailed and comprehensible accounting representation of the players in the economy and their relationships with each other (Vanoli, 2019a, p. 26; see also Box 1). Markets were dysfunctional and unbalanced, and the productive apparatus was partially destroyed or lacking in raw materials. The State then provides a representation of these problems in order to resolve them. Non-financial intervention in the economy included price and exchange rate controls, fiscal instruments, public investment and control of wholly or partly nationalised companies (Fourquet, 1980). It was made possible by observation of the past and forecasting, as well as by major consultation bodies bringing together employers, trade unions and the General Government. The purpose of the specialised accounts created at the time was to provide everyone with reliable, detailed information on certain sectors or strategic issues, so that these tools could be used in a coordinated and effective manner (Vanoli, 2002).

Box 1: The objectives of French NA in the 1950s

If we look in more detail at France, the crucible of an extensive link with business accounting, we can note the objectives that Claude Gruson had in mind when he laid the foundations of 'modern' national accounting in 1950 (emphasis added):

"The NA must] **reflect the evolution of an economy** over given periods, and it must make it possible **to draw up economic budgets** capable of showing the major trends in the economy and the changes that are taking shape. These economic budgets provide the information needed to give **meaning to budgetary action, but also to all economic policy decisions** (prices, wages, foreign trade, etc.)". (Terray, 2003, chap. II)

It is a reaction to the Anglo-Saxon approach, which proposes a reduced number of aggregates:

"By constituting a simple totalisation, it misses the **essential relationships within the national economy** itself, which can only be seen if a number of sectors are distinguished and if the transactions and links that unite them are highlighted separately". (Terray, 2003, chap. II)

This is how it works:

"The task assigned by Claude Gruson to his small team was to draw up a national accounting system that would enable the preparation of a national economic budget²³. This would serve as a framework for the annual State budget, based on a forecast of the main elements of general activity. This forecast is based on a system of equations between the various elements of the economic circuit". (Terray, 2003, chap. II)

These objectives remained in place for more than 15 years, until the changes in direction decided by General de Gaulle in 1958 really took shape during the reorganisations carried out by Jean Saint Geours in 1967. These changes coincided with the introduction into INSEE of approaches and people trained in microeconomics. The growing influence of econometrics, on the one hand, and the calculation of the profitability of public investment, on the other, can be noted. (Terray, 2003, pp. 407-437).

The main focus is therefore on the study of imbalances between uses (Intermediate and final consumption, investment) and resources (production and imports) in the Input-output tables²⁴. This has led the French to go into much greater detail in this table (several hundred products). Intermediate consumption is therefore essentially a tool for checking the consistency of goods and services accounts, but not a forecasting tool. (Vanoli, 2002, p. 99)..

Similarly, the early development of financial accounts in France (as was also the case in the United States) is linked to the policies of the time. Inflationary concerns were under the government's watchful eye. This was particularly true in France, where the "Treasury circuit"²⁵, which fed into the

²³ We reproduce Terray's note here: "Claude Gruson's principles and his model were published for the first time in July 1950, in the "Note sur les conditions d'établissement d'une comptabilité nationale et d'un budget économique national", *Statistiques et Études financières*, No. 19, July 1950, pp. 517-538.

²⁴ Internationally, the dominant trend in analysis focuses much more on technical relations between industries (study of changes in technical coefficients, and use of the Intermediate consumption table for forecasting).

²⁵ Between the 40s and the 60s, the Treasury had an account with the Banque de France. Government departments and nationalised companies (all commercial banks were nationalised after the war) deposited their

Plan, was capable of generating monetary imbalances. The financial accounts are also used to analyse the financing of investments. (Fourquet, 1980; Vanoli, 2002, p. 111). This time, the links were forged with government accounting. The State's mastery of most of the financing circuits of the time made this connection a natural way of managing the different mechanisms jointly (Fourquet, 1980; Lemoine, 2016).

So we can see that, despite similar institutional structures and contexts, the designers' idea of how the economy works also plays a role in the accounting policies they choose.

2.3.2.5. Adapting NA to the internationalisation of economic policies

The second aspect that emerged in the 1950s, and which continues to this day, is the trend towards harmonisation of frameworks. The aim is to compare countries (which certainly helped launch them into a race for growth), but also to enable them to exchange and coordinate when necessary or desired (particularly in the context of international aid or the construction of common economic areas such as the European Union or trade agreements). This aspect is linked to the new wave of globalisation.

The comparability of accounts at international level is increasingly sought after, but this will only really be possible from the 1960s onwards, and not necessarily in a complete manner (Vanoli, 2019a, p. 24). At European level, even before the methodological reconciliations had been completed, the National accounting system was used to harmonise and reconcile the economic policies of the member countries (Archambault et al., 1992, p. 86). In 1974, the Council of Ministers decided to examine the aggregates (Table 2) every quarter with a view to making recommendations to the member countries. These recommendations came at a time when their respective budgets were being drawn up. Annual and five-yearly reports were drawn up by the Commission and adopted by the Council after consultation with the European Parliament and the Economic and Social Committee (ibid.). In 1990, this system was strengthened with a view to the establishment of economic and monetary union. Recent trends in the indicators are given, as well as their probable development over the next two years. The absence of a breakdown (or only between institutional sectors) is considered sufficient to study the general equilibrium of an economy and the effects of budgetary and monetary policies (ibid., p.89).

funds in this account. In this way, the Treasury had direct access to a very large proportion of the country's short-term savings to finance (again in the short term) a wide range of expenditure. This system of State financing was central to the implementation of the five-year plans.

Table 2 Indicators selected by the Council of Ministers to harmonise and converge European economies (Archambault et al., 1992, p. 87)

Indicator used	Adequate representation of:	Differences in definitions between member countries limit comparability
Gross domestic product, domestic demand, Gross fixed capital formation	Activity and the main components of demand	
Changes in the implicit prices of GDP and private consumption	Global measures of inflation	
Changes in nominal unit labour costs	Pressure from wage costs	This calculation requires an assumption to allocate to the labour factor a share of the income of sole traders
Current account balance (% of GDP)	All transactions with the Rest of the World	
National savings, measured as a % of GDP		
General Government borrowing requirement (as a % of GDP) and public debt (as a % of GDP)	The results of current and past budgetary policies	The notion of General Government is accepted differently from one country to another due to institutional differences In addition, public debt is either net or gross, depending on the country.
Changes in total employment and the unemployment rate	Overall labour market indicators	Some countries did not use the definition of the number of people engaged in productive activity, but rather the volume of work done (man-years).
Long-term interest rates and real effective exchange rates	The situation on the financial and money markets	There are several methods for calculating exchange rates, depending on whether the focus is on imports or exports
Level of gross domestic production per capita, expressed in purchasing power standards	Global standard of living indicator, making it possible to measure the catching-up process taking place in certain countries.	

Archambault et al (1992, pp. 89-93) then give two other examples: analysis of the sectoral effects (gains and costs) of monetary union in relation to the more macroeconomic situation. Without going into detail, it should be noted that in the first case, National accounting figures were used to validate and put into perspective surveys of different sectors on specific issues. This use of data consistency is often cited by National accounting. It is very important, but because of its nature as an intermediary use, we will not return to it much in this thesis, focusing instead on uses that have an effect in terms of action. In the example given by Archambault, the National accounting also served as input values for econometric models used to establish scenarios.

The second example is the use of GDP, then the VAT base, and finally Gross National Income (GNI) to estimate the contribution of member states to the EU budget. Here, it is the European institutions that introduce the values they are given into a simple calculation to get the Member States to contribute money. Today, the estimation of GNI is the subject of fairly cumbersome reporting systems to validate the funding of the European budget (Hauseux, 2020; Magniez, 2009).

Tinbergen (Vries et al., 1993, p. 14) cites the use of national accounts in the development aid policies of newly decolonised countries. This was a factor in the development of NA in these countries. But a

particular use was also made of national accounts in the countries providing the aid in question: it was decided that they would contribute 0.7% of gross national production. In the same vein, the World Bank allocated subsidised loans on the basis of GDP or GNP (Vanoli, 2002, p. 564).

More broadly, globalisation has created a need for international regulation. The IMF is taking on the role of watchdog and is helping to manage local and regional crises. In this way, it became both a user of and a requester for harmonised statistics (Vanoli, 2002, p. 565). National accounting is therefore essential, even if other sources are also used to study financial movements on the world's capital markets, speculative bubbles and so on.

In this section, we see that new influences are shaping the conventions, without going so far as to create new accounts. Users are pushing for greater or lesser alignment of methodologies, or emphasising certain aggregates (Gross National Income rather than Gross Domestic Product). Each user and each use brings its own set of changes, which may be more or less far-reaching, but they are significant. However, compared with the 1930s, when the first blocks of NA were still very malleable, the changes envisaged 40 years later are much less profound.

2.3.2.6. NA meets limits with (neo-)liberalisation

The first years of the 1970s saw Keynesian policies, planning (particularly French-style) and national accounting come up against limits and the emergence of a new form of neo-liberal state (Table 1; Desrosières, 2008a).

Internationalised, then globalised and increasingly complex economies are challenging accounting categories (Vanoli, 2002). As a result, flows, particularly international and financial flows, are more difficult to track; companies with increasingly complex structures and ramifications are less clear-cut entities (hence the gradual move towards "profiled" companies, moving away from the legal structure alone); and intangible investments (R&D, digital) have been slow to be incorporated into the NA. These three limitations seem to us to be primarily technical, i.e. linked to the quality of measurement. Accounting is faltering, because the trust that can be placed in it has been diminished, but these limitations do not affect the very functions of NA, which can still be used for the same purposes. These limits are gradually being overcome, with varying degrees of success, between the end of the last century and the present day.

Perhaps more problematically, the economic policies used up until the mid-1970s were no longer as effective in tackling unemployment, inflation or growth. At that time, macroeconomic regulation policies and social policies were even considered to be the cause of crises, leading to a sharp decline in state intervention in their areas (Desrosières, 2008a, p. 51). From an institutional point of view, this corresponds to the period of strong liberalisation of the British and American economies under Thatcher and Reagan and the retreat of statistics in these countries. In France, planning underwent this change gradually, with the latest plans becoming less and less effective (de Gaulle, 1994; Fourquet, 1980) until the five-year plans were abolished in 1993. This was followed by the transformation of the Commissariat général au Plan into the Centre d'Analyse Stratégique in 2005. The INSEE seems to have been relatively unaffected by these changes, in particular because of the increased demands from supranational levels and from new users ("who ignore each other" according to Vanoli, 2002, p. 561) neoclassical modellers who build computable general equilibrium models. However, they make much less use of time series. They rely on NA data for one year (sometimes several years, averaged), supplemented by external data. While the scope of NA frameworks has been greatly reduced, which automatically implies less use of NA, this does not mean that NA has disappeared.

Unlike liberal policies, which still placed the State at the centre of action, neoliberalism is based on polycentrism, with supra (e.g. European) or infra (Table 1; Desrosières, 2008a). These policies, based on individual incentives and contractualisation, are becoming increasingly widespread. This shift in focus from the State and macro-aggregates to organisations and the microeconomic level has also had an impact on information, particularly statistical information. But this trend is leading to the production of more indicators (Desrosières, 2014, 2008a, pp. 53-55). The aim is to create *benchmarks* and rankings to compare players (public or private). New Public Management, which focuses on public-sector players, is part of this approach, organising the production of performance indicators to evaluate public administrations and bodies²⁶. This change is justified by the loss of confidence (rightly or wrongly) in the sense of public service of these organisations following their autonomisation and the decentralisation of many competences²⁷ (Desrosières, 2014, chap. 1). Changes in accounting standards towards *International Financial Reporting Standards* (IFRS, issued by a private foundation), which give greater weight to shareholders to the detriment of the State or managers, are a step in the same direction, according to Desrosières. Desrosières (2014).

A second consequence of neo-liberalisation is the relative abandonment of the idea of exhaustiveness and articulation within a single set of accounts. The EU's 'open method of coordination' is thus based on the introduction of policies whose achievement is assessed by means of objectives expressed in words, negotiated by politicians and then quantified (and monitored) by statisticians (Desrosières, 2008a, p. 71). In this way, policies are broken down and quantified relatively independently of one another.

It is worth noting, however, that there has been a complementary movement in the wake of neo-liberalisation, namely the synthesis of Keynesianism and neo-classicism. This led to the 'recycling' of national accounts to feed general equilibrium models. These models, which tend to be developed by research establishments and forecasting institutes, are based on raw NA data and slightly reshape the input-output tables using assumptions that differ from those of the Keynesians.

Lastly, from the 1970s onwards, the notion of growth underwent paradoxical changes: on the one hand, there were fewer policies aimed at absolutely increasing growth, in favour of short-term policies (which led to the creation of quarterly or even monthly accounts), social policies or structural transformation policies (Vanoli, 2002, p. 559). But on the other hand, GDP remains central in the discourse, even becoming an indicator that is supposed to reflect well-being. This interpretation of GDP is widely criticised, however, because of two fundamental limitations of the NA: the failure to take account of environmental issues and inequalities.

Thus, this period saw three joint developments. Firstly, in order to maintain certain practices, it may be necessary to reshape accounting methods and frameworks so that they remain adapted to what they wish to represent. Secondly, when part²⁸ or all of the NA²⁹ is called into question, more or less radically different alternatives emerge to meet new needs.

²⁶ For example, in water policy (Canneva and Guérin-Schneider, 2011).

²⁷ Previously, the more hierarchical relationship they had with the central government, the bearer of the public service ideal, guaranteed the feeling that it was being followed as closely as possible to the citizen.

²⁸ The ability of GDP to reflect the salient aspects of a country's desired destiny.

²⁹ The users and methods of intervention that prevailed at the origin of the accounting framework are now in difficulty.

2.3.2.7. *Two crises with different impacts: the 2008 financial crisis and the Covid crisis*

The financial crisis of 2008 made it necessary to mobilise the NA's financial accounts and highlighted certain shortcomings which were then addressed by the statisticians. These new and urgent demands have partly reshaped the NA. For example, the delay in constructing wealth accounts (particularly financial) was quickly made up for by improving their recording time, their international dimension and their relationship with the real economy (Bos, 2017). Gaps in the Households accounts have been filled (particularly in the United States), as have those on public intervention in the financial system and their interaction with public finances (in the EU). International institutions have also filled regional gaps.

The work in progress for the revision of the UN System of national accounts, which will take place between 2020 and 2025, indicates the priorities identified by the international accounting community. In particular, we note that the 2008 crisis has led to changes in the financial aspects, which are currently being discussed, but also in the digitalisation of the economy, and in environmental issues (which are linked to the question of well-being), which have been gaining in importance since the 1990s.

More recently, the Covid crisis showed that modern Keynesian analyses were essential. Indeed, as the radical policies implemented (confinements) had a direct impact on supply and demand, it was necessary to assess the induced effects and create palliative measures (see for example Dauvin and Sampognaro, 2021; Martin et al., 2020). The differentiation between sectors of activity and income categories, which have been affected differently by the crisis, has posed some challenges for statisticians in publishing short-term information. But overall, Blanchet (2022) and Timbeau (2021) consider that the NA has played its role well and proved particularly robust.

Stimulus packages (more or less greened for the occasion depending on the country) have brought back to the fore the need for substantial budgetary intervention (particularly in the United States and the European Union), combined with delicate inflation management. It is expected that the NA will be heavily involved in better targeting stimulus measures, particularly when they involve re-industrialisation.

This period illustrates the ability of crises to make management tools evolve more rapidly, but also that certain doctrines of action can come back to the fore.

2.4. Accounting brings a special flavour to this form of statistics

This section illustrates the diversity of uses of National accounting and how these have influenced the accounting structure. More broadly, the link with conceptions of State action, i.e. what the State is allowed to do in the economy, and the way in which it organises itself with other States is presented. There were four main developments in the use of NA, which still have an impact today:

- The end of planning in some countries has reduced the use of NA, but it continues to feed into government budgetary policy (mobilisation around and during parliamentary discussions of finance bills in particular).
- The NA continues to be used at international level: it fuels the alignment of the European common market (with the creation of new benchmarking tools, more or less linked to the NA) and financial exchanges between countries and international institutions.
- A new field of statistics is emerging under the impetus of neo-liberalisation and decentralisation: performance indicators outside any NA framework.

- The NA is mobilised in a relatively similar way to the past in the event of a crisis (financial crisis of 2008, health crisis) and economic recovery. Keynesian approaches have not been abandoned, but have been modernised when they re-emerge.

In the light of history, it is possible to offer a summary of the uses of NA based on the main functions of accounting (Stolowy et al., 2010) ES: counting, recording in accounts, rendering an account, being accountable for one's actions.

The function of **counting** corresponds to the creation of a common, quantified language to express phenomena previously described only in words. This dimension refers to the use of quantification as a language for representing reality. Representation in a quantified form requires a number of operations to select the dimensions deemed relevant by users: perimeters, choice of characteristics to be measured, measurement procedures, coding of information according to simplified categories to compare the different entities, possible aggregation of several characteristics to produce a summary, and so on. A key dimension of this work is commensuration, "the most socially transformative form of quantification" (Espeland and Stevens, 2008). It is "the evaluation or measurement of different objects using a common metric" (ib.). This involves creating a common cognitive space, comparability and a levelling out of all differences in a single metric, which becomes the only axis of differentiation (quantitative and unidimensional).

As far as the NA is concerned, this function has been used extensively at two points. First, in the first estimates of national income, especially when statistical methods were involved. The equivalence space created was the nation. The phenomenon supposed to be represented by this quantity was power and wealth (with varying degrees of success, the notion of progress was attached to it in the 1970s). (Fourquet, 1980; Lachaize and Morel, 2013). Then came the introduction of the accounting framework, which brought about a twofold movement: on the one hand, the bringing together of many different concepts quantified with a single unit of account (the value of money); on the other, the creation of increasingly detailed typologies of what was covered by these different concepts themselves (production, economic activities, assets, etc.). These typologies were recycled, translated and reformatted, and came either from business accounting or from administrative registers (statistical units such as legal enterprises, Households, etc.). Others were created from scratch, such as industries. In so doing, elements have been included or excluded: see the discussions on productive or non-productive activities³⁰, domestic work, or R&D expenditure, to name but a few. (Fourquet, 1980; Vanoli, 2002).

The function **of recording in accounts** is specifically linked to the accounting structure (whereas other functions may exist for isolated indicators). Accounts are the minimum recording units. They have specific relationships with each other, which are governed in particular by the obligation to record transactions using the double-entry method. The set of accounts represents and models the system of interest. As a result, the accounts may exclude or reject entire areas of the business that we wish to manage.

Once again, the introduction of the accounting structure into National accounting statistics was a key moment. Previously, aggregates had been relatively isolated or had been able to maintain more

³⁰ Here are a few examples: the back and forth concerning services; the definition and inclusion or not of General Government "production" was late in France; military activities were not considered productive before the 2008 SNA; services produced by Households for their own consumption are still not considered productive.

flexible relationships, depending on the modelling (non-linear relationships, etc.). Its partial rejection in the neo-liberal era is another: each aggregate, each policy, is atomised. In both cases, it is a question of ratifying or rejecting the articulation of issues, policies and players.

The "***giving an account***" function corresponds to the presentation and communication of a state of affairs, and in particular of what has been done. It is the basis for discussion, justification and debate between the players involved in the object represented. This function supports the direct manager, but also the stakeholders with a greater or lesser interest.

Canonically, around the BA, it is essentially politicians who deal with businesses and citizens. This function has been present throughout history, but with different shades of colour. It was present from the earliest estimates of national income, which were used to estimate tax bases. The isolated aggregates and then the complete NA are then used to define objectives (for growth, deficit, development of a particular sector, etc.) and public policy actions based on a description of the state of the economy. These objectives and actions are negotiated between the executive, the legislature (bringing together the representatives of the citizens), and various stakeholders representing all kinds of interests. In this way, all budgetary policies (and the way they are framed, for example by framing them in terms of percentages of GDP), structural policies, and possibly financial policies (framing the level of public debt) and monetary policies are based on this function: evaluation of the relevance of a policy (ex ante or ex post), calibration, targeting, etc. are controlled and discussed using the NA or its translations³¹.

Finally, the function ***of being accountable for one's actions*** organises relations and interactions between actors according to 'accountability' regimes (Feger et al., 2018) i.e. responsibility towards each other. Here, accounting meets law. The notion of liability, in particular, is at the heart of this function. But income, for example, is also the basis for profit distribution within the company, or redistribution. The value of assets is central to bankruptcy.

In NA, this function was (and still is) used in two cases.

The first is post-war planning. In France, as in the Netherlands, it was the basis for discussions between social actors who were directing and taking part in economic life by being accountable for their actions, expressing their needs, their constraints, and so on. The full use of the coordinating function of accounting (because we are talking about organising an economy from within) in the Netherlands and France is a historical parenthesis and a relatively isolated case in market economies. This is probably what led Vanoli (2002) to speak of a relative crisis of the NA from the 1970s-80s onwards. Although it is clear that interest in National accounting declined in many countries (notably the UK and the Netherlands) during this period (Vries et al., 1993) the idea of crisis is not as present in other writings (Bos, 2017).

³¹ Lachaize and Morel (2013) consider state rating and forecasting as uses. In this case, we would tend to link them to the accounting function. To consider them as end uses is debatable. Rating, like all analyses using ratios or time series, is a reformatting, a translation of accounting information in order to interpret it. Similarly, forecasting, based on models founded on NA, seems to us to be more of an intermediate domain producing new information. It is a kind of translation, reformulation or extension of NA.

The second case involves indexing the budget to the macroeconomic variables already mentioned (financial exchanges with international institutions)³². National accountants are somewhat uncomfortable about having been chosen for this type of exercise, as it requires them to meet user requirements that they do not master, which are sometimes enshrined in law and which hinder developments in the accounting framework (for example, European administrations ask them to produce gross national income, the conventions of which differ from those of GDP).

This analysis of uses through the prism of the four accounting functions opens up avenues for the environmental extension of the NA. As these functions are used in economic policies, it is reasonable to imagine extending them to the environment. This raises a number of questions. What kind of quantification and commensuration should be used between environmental objects and in relation to what economic concepts? What common language are we going to create for which players? What conceptual links should be established between the economy and the environment? What uses of economic NA can be replicated or adapted to manage the environment? How should responsibilities be allocated? Finally, like Desrosières, can we imagine a new form of State emerging if particularly new instruments, statistics and concepts of the State-economy relationship appear?

These questions will be addressed later in this chapter and in this thesis.

The second part of this chapter aims to set out the starting points for our work, this time concerning the introduction of the environment into the "representation - action - governance" triptych.

³² There are other indexations based on statistical quantities: some are used as a basis for indexing taxes or subsidies (indexation to inflation, the price index, etc.).

3. The challenges of integrating the environment into NA

3.1. How do environmental issues fit into the representation-action-governance triptych?

Environmental issues have a potential impact on the whole triptych (Figure 5). Existing accounting systems could incorporate environmental information (Feger and Mermet, 2021a) either in satellite form (in business accounting terms, we would say extra-financial) or in the central framework (in standardisation). Public interventions for the environment are often of the same nature as those used to guide economic behaviour (schematically: regulation, economic instruments, spatial planning, etc.). Moving up a level, we find that companies are communicating more and more about their social and environmental policies, detailing increasingly precise objectives and action plans. But the governance of economic issues still leaves out environmental players. One of our working hypotheses is that this is partly due to a lack of common language and representation of environmental issues in accounting.

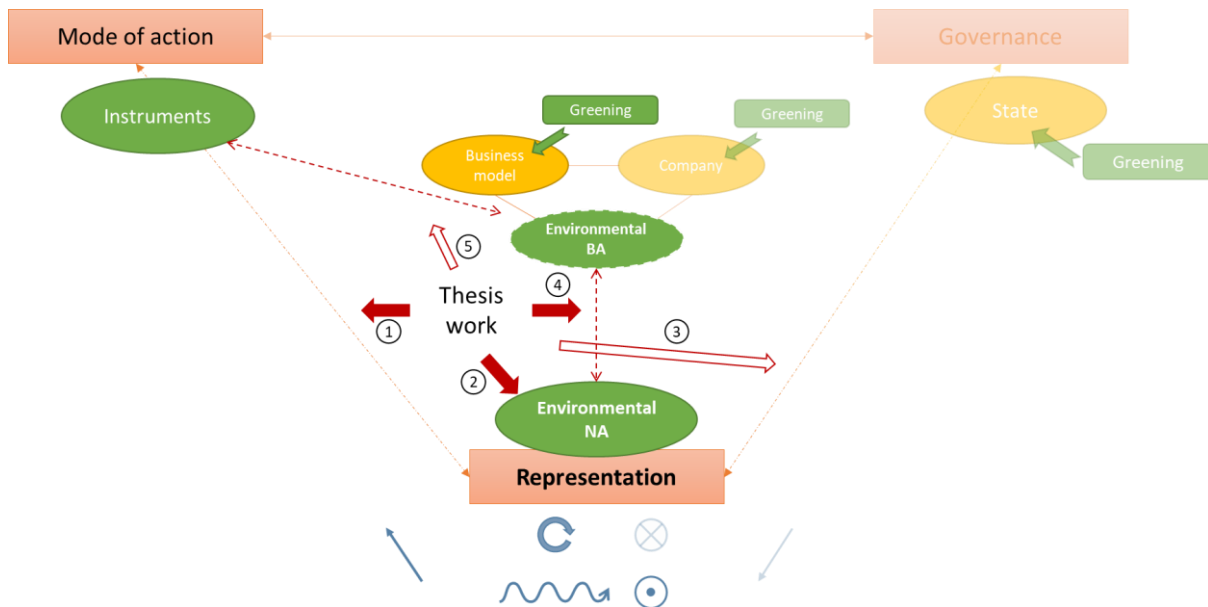


Figure 5 Green accounting workspace.

Legend: solid red arrows: subjects covered in depth; empty red arrows: subjects covered in a secondary manner. The numbers indicate the chapters of part 1 where the work is initiated (chapters 4, 5 and 6 of part 2 deal with all of them). The blue pictograms no longer represent factors determining conventions as in Figure 1 but the different perspectives we will use to (re)work on accounting policies: the arrow on the left for the "usage" perspective, the thick arrow that closes in on itself for the "accounting constraint", the zigzag arrow for the "historical" perspective, the cross in the circle (arrow seen from behind) for the "theoretical" perspective, the dot in the circle (arrow pointing towards the reader) for the "methodological" perspective and the arrow on the right for the "governance" perspectives.

In this thesis, we will look at various aspects. Firstly, the design of an accounting system according to the principles of strong sustainability is at the heart of the work. To do this, we will essentially take four perspectives:

- to understand the trajectory and controversies that have shaken the field of environmental NA;
- users, through a discussion of the possible uses of the accounts and proposals for connecting such accounting with existing public policy frameworks;
- methodological approach, by discussing possible sources of data for this accounting;

- the accounting constraint will be approached from the angle of consistency with economic NA. We will try to take up the principles and concepts of economic NA to see if and how the environment can be included.

The theoretical and governance perspectives will be discussed more marginally (the second is in section 3.3).

This section is organised as follows. Firstly, we will start with the proposals for environmental accounting to map the main approaches currently being developed. This will be an opportunity to see their level of development, as well as the links between national and company proposals. This will give us an idea of the work that needs to be done.

We will then adopt a "uses" perspective to see what (if any) patterns of change underlie the current proposals. This will enable us to show the potential of National environmental accounting for managing ecological crises.

3.2.NA for the environment: a field still in flux

This section sets out to define the field of environmental NA, which is still in a state of flux. Although standardised under the aegis of the UN, major innovations in environmental NA are still emerging, or have been sidelined in the past. We therefore feel that a classification of approaches is necessary, if only to find one's bearings in a world where the proposals are rich and technical, and where it is often in the details that the proposals stand out. Beyond this aspect, we feel it is important to classify them according to their potential effects. This requires an understanding of at least two key aspects.

The first is the unit of account (biophysical or monetary), which determines the possibility of integrating environmental information to a greater or lesser extent with that relating to economic or financial issues. This also has an impact on potential users: schematically, detailed biophysical data is directly useful for managing the environmental issue in question, while monetary data is used to discuss trade-offs between major issues and public policies.

The second is the concept of sustainability (weak or strong). The level of requirement, in terms of what we wish to conserve, is an essential positioning point for our work, but also more broadly for any environmental policy. In the case of weak sustainability, it is the total aggregate 'capital' that we wish to preserve, i.e. the sum of the values of financial, social and environmental capital, with the possibility of compensating for the loss of one by others. On the other hand, if we are aiming for strong sustainability, we want to conserve a set of 'sub-capitals' individually, without the possibility of offsetting them.

In addition, the (as yet weak) link with (proto)-accounting³³ is described.

3.2.1.Map of accounting proposals

Since the 1990s, a wide variety of approaches to integrating the environment into National accounting and Business accounting have been developed.

³³ "Evaluative Conservation Information Systems (ECIS) that seek to play a direct role in a diversity of ecosystem conservation decision-making, organisational and institutional processes" (Feger, 2016, p. 118)

In environmental national accounting, no comparison or synthesis of complete systems has been made to our knowledge. Since its creation, the SEEA has aggregated, converged and taken over all or part of systems built prior to the 1990s. Parts of these systems were therefore analysed from a functional point of view. There is no document from the time that provides evidence of a synthesis on the subject, but a mapping of approaches can be found in the work of Radermacher (2020, Figure 6). Another way of comparing approaches is to take an interest in the debates that run through environmental economics and ecological economics: the sticking points lead to the development of indicators or accounts with different conceptual choices. The question of whether sustainability is strong or weak can thus be linked to the choice of biophysical or monetary reference unit (Dietz and Neumayer, 2007).

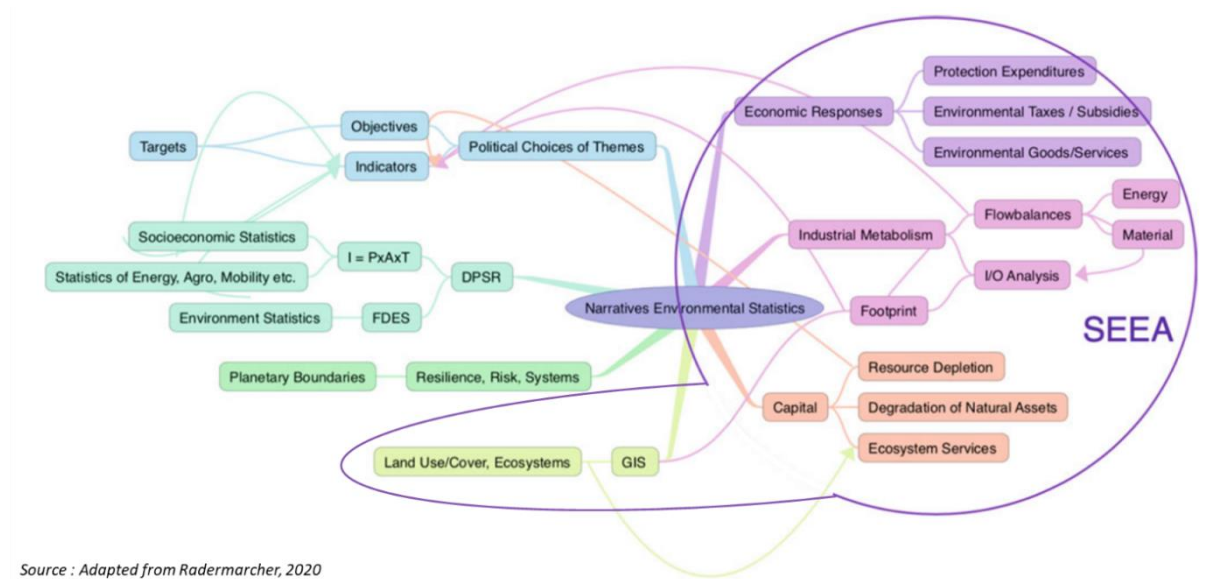


Figure 6 Description of types of National accounting approaches

On first analysis, Figure 7 and Figure 8 show where the main approaches discussed in this thesis fall along two particular axes: the choice of unit of measurement and the conception of sustainability. To understand how the approaches have been classified along this second axis, the reader is referred to the discussion in Chapter 3.

Figure 7 contains national approaches classified into three main groups. The purple ellipse brings together approaches that could be described as "economic": these are works carried out or influenced by economists and national accountants without the direct involvement of environmentalists (researchers or practitioners). The approaches in the orange ellipse, on the other hand, were designed by practitioners or public players involved in ecosystem conservation. Finally, in red are systems that have been developed at the confluence of the two communities. These are true accounts that combine biophysical indicators and monetary accounts in different ways in very rich information systems. Our thesis work focuses mainly on these approaches, which are the most integrated.

The three sub-communities working on National accounting are relatively permeable and exchange explicitly while understanding each other well, in particular through integrated approaches. The creation of Natural Heritage Accounts in France in the 1980s (Commission interministérielle des comptes du patrimoine naturel et al., 1986) and the SEEA since the 1990s, show that a fruitful dialogue can take place between ecologists, specialists in pollution or natural resources, statisticians, national accountants and economists. This has even been of considerable importance in the revision of the SEEA's ecosystem accounts.

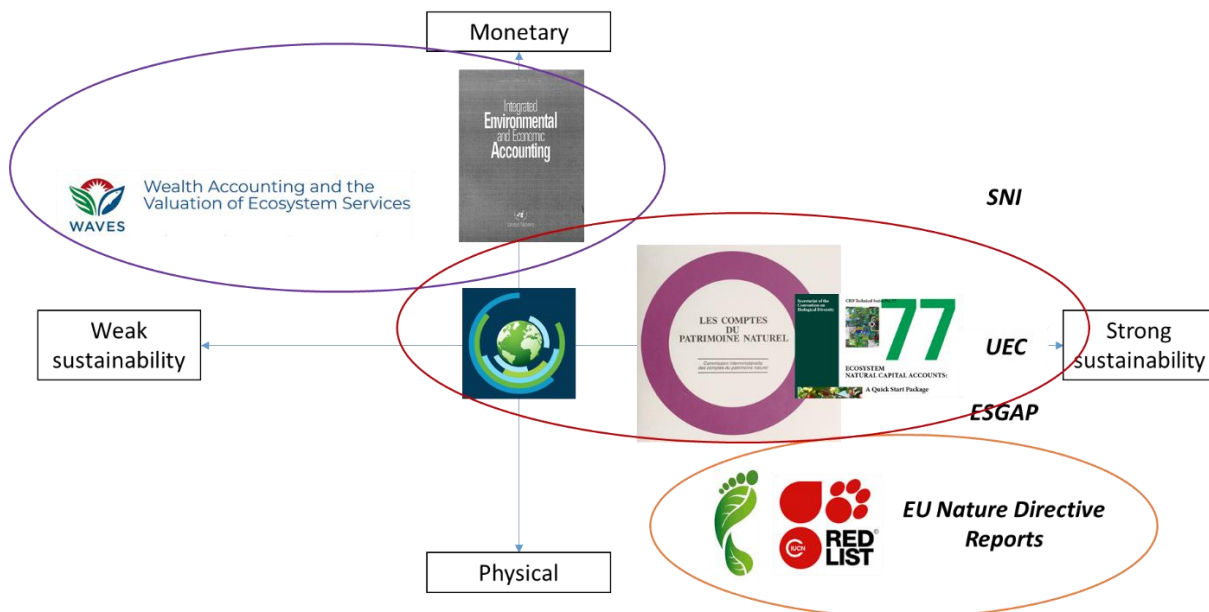


Figure 7 Mapping of (proto-)national accounting approaches according to their unit and their connection to sustainability

Legend: The proximity of a pole indicates a clear choice that excludes the opposite. The intermediate position indicates either the joint use of monetary and biophysical units (vertical axis), or an ambiguous conception of sustainability (horizontal axis). From top to bottom and left to right: WAVES; cover of Integrated Environmental and Economic Accounting 1993; (recent) logo of the SEEA; cover of the Natural Heritage Accounts; cover of Ecosystem Natural Capital Accounts (a quick start package); logo of the Ecological Footprint; logo of the IUCN Red Lists; European reports under the nature directives ("habitat", "birds", "water", "marine environments").

If we extend the number of proposals made for the national level, we see that there are varying degrees of integration of these proposals into accounting. The least integrated are the information systems on environmental indicators, which can be isolated (for example, those of observatories such as the French National Biodiversity Observatory) or brought together in dashboards (sustainable development objectives). More coherently, we then find monitoring linked to regulations (European reports for the European nature, water and marine environment directives), or unconnected with them (red list of threatened species) which take a relatively comprehensive interest in a type of ecological entity (species, habitats, etc.). The ecological footprint attempts to cover a relatively broad environmental field (CO₂ emissions, pollution of ecosystems, consumption of natural resources) and combines them into a single indicator. Similarly, the *Environmental Sustainability Gap* (Ekins et al., 2019; Ekins and Simon, 1999; Usubiaga-Liaño and Ekins, 2021a) is a measure of a country's sustainability. It is calculated in three stages: compiling a list of environmental indicators; calculating the percentage sustainability gap for each indicator; and calculating the geometric mean of these percentages.

Environmental satellite accounts are much closer to accounting, since they explicitly adopt its principles. (Vanoli, 2002, pp. 257-258). They may be officially published, which is the case for the environmental economy accounts (Bourges et al., 2018) forestry accounts, or experiments on carbon, air and inland waters (CGDD et al., 2015). Several approaches involving modelling have gravitated around National accounting: true savings (Hamilton, 2000, 1994; Pearce and Atkinson, 1993; World Bank, 2006) Rufie Hueting's *Sustainable National Income* (Gerlagh et al., 2002; Hueting, 1980) and the Unpaid Ecological Costs of Vanoli (2017, 1995). An original and relatively unique academic proposal concerns the inclusion of ecosystem services linked to recreation in a satellite account very close to the central framework of National accounting (Martin et al., 2018).

Finally, truly integrated national accounting could emerge from the SEEA (in addition to the approaches listed in the figure, there are: Bureau of Meteorology, 2013; Weber, 2014).

Figure 8 is a graph ranking the business proposals along the same axes. It contains ellipses of the same colours to indicate a certain kinship with National accounting approaches. In business accounting, the proliferation of approaches since around 2015 has led a number of authors to make comparative assessments, using various criteria (DFCG and Ordre des Experts-Comptables, 2021; Lammerant et al., 2021, 2019, 2018; Rambaud and Richard, 2016; WWF France, 2021). Boyer (2020) Based on this work, Boyer has constructed a comprehensive analysis of accounting design choices and related controversies. The main approaches are summarised here.

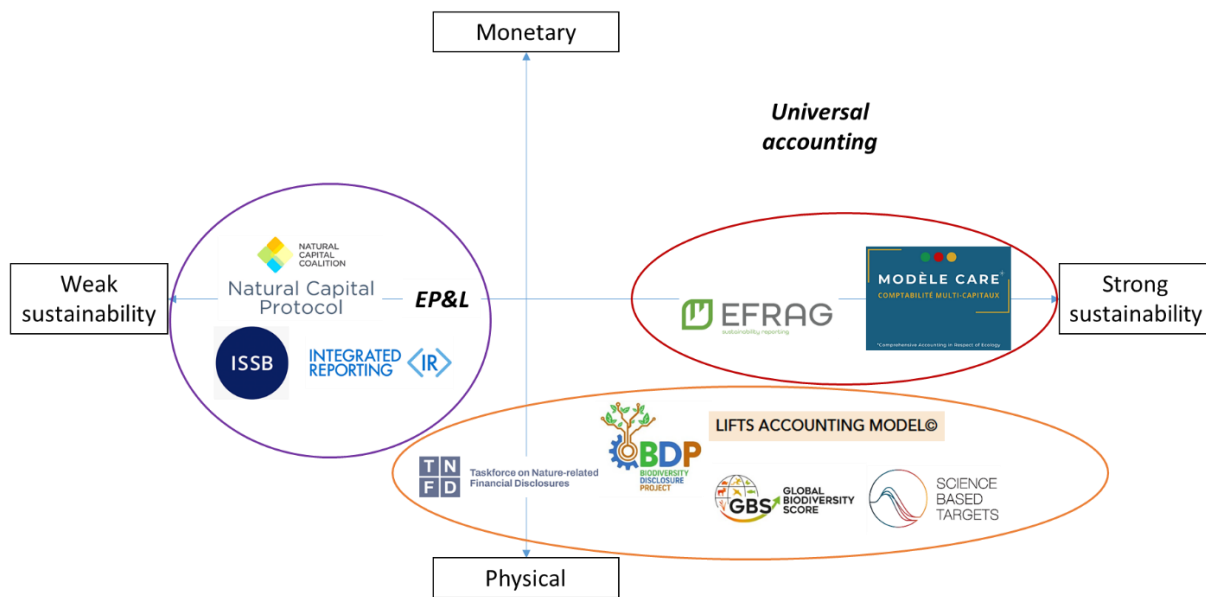


Figure 8 Mapping of (proto-)accounting approaches for organisations according to their unit and their connection to sustainability

Legend: Only biodiversity-related approaches are cited. The proximity of a pole indicates a clear choice that excludes the opposite. The intermediate position indicates either the joint use of monetary and biophysical units (vertical axis) or an ambiguous conception of sustainability (horizontal axis). EP&L: Environmental Profit and Loss; ISSB: International Sustainability Standard Board; EFRAG: European Financial Reporting Advisory Group; TNFD: Taskforce on Nature related Financial Disclosure; BDP: Biodiversity Diversity Protocol; GBS: Global Biodiversity Score.

Weak sustainability approaches (purple ellipse) are influenced by the desire to produce information for investors, from a financial perspective. These methods explain how to measure and declare the risks and opportunities arising from a change in the state of the environment. This is based on the concept of Ecosystem services and their monetary valuation. The orange ellipse shows several approaches developed in conjunction with the ecological sciences to measure the biodiversity footprint of businesses. This is the case of the *Biological Diversity Protocol* (Houdet and Germaneau, 2014) and the *Global Biodiversity Score* (Berger et al., 2018). Others fall within the very broad field of social and environmental responsibility, with a view to proposing principles and definitions that can serve as a basis for standardising extra-financial reports (Lifts, TNFD, Science-Based Targets). Finally, the only fully integrated approach geared towards strong sustainability that seems to exist is the CARE (Comprehensive Accounting in Respect of Ecology) model developed by Rambaud and Richard (2015; Richard, 2012). The European Financial Reporting Advisory Group (EFRAG) has standardised a

sustainability report that lays the foundations of the CARE model, but only from a biophysical perspective for the time being.

Box 2: Ongoing standardisation of corporate sustainability reporting

At the time of writing, the landscape of extra-financial reporting proposals is changing rapidly. In addition to the models mentioned Figure 8 most of which have been in existence for at least five years, regulations and voluntary approaches are flourishing. The European Union has launched a standardisation process for extra-financial reporting, with the aim of producing information that complies with the principle of "double materiality". This involves producing information on both the impact of companies on the environment (pressures and positive impacts; sometimes referred to as ecological materiality), and on the effects of a change in the state of the environment on companies (risks and opportunities; referred to as financial materiality). Two directives are currently being drafted: the *Sustainable Finance Reporting Directive* and the *Corporate Sustainability Reporting Directive*, which, once transposed into French law, will replace the Extra-Financial Performance Declaration (EFRD). The *Global Reporting Initiative* has taken a position on double materiality, while the *International Sustainability Standard Board* (ISSB), the foundation that produces the IFRS (*International Financial Reporting Standards*), is developing a single materiality reporting standard in response to the EU's work.

Because these approaches are still relatively fluid, we will not rely on them in the context of this thesis. However, EFRAG's work lays the foundations of the CARE model in regulation. Without going so far as to describe an accounting structure or monetary valuation methods, they contain several elements. Firstly, the monitoring of biodiversity impact metrics, which makes it possible to define the entities to be preserved, or capitals (see next section). Secondly, the objectives to be achieved (CARE preservation thresholds) and the contribution to respecting global limits, the objectives of the post-2020 framework (resulting from the COP15 negotiations) and the objectives of the European 2030 biodiversity strategy. Finally, the actions planned by the company.

At the level of organisations' environmental accounting, exchanges between communities (between ellipses of different colours) are more difficult. The tensions surrounding the debates on sustainability and monetary valuation are complicating discussions and joint work. So far, the different circles have worked quite separately. In parallel with the standardisation work on corporate sustainability reporting that has been underway since 2020 (see Box 2), the group working on biophysical indicators has moved closer to integrated and monetary accounting methods (thanks to the European project *Align-Aligning accounting approaches for nature*³⁴ for example). The Align project does not use an integrated accounting model, but is open to accounting principles and standardisation. This can be seen as a first step in the direction indicated by Feger et al (2018) to bring the conservation and accounting communities together to build ecological accounts.

3.2.2. Description of three accounting systems at the heart of this thesis

Given this wide variety of approaches, this thesis will focus on three accounting proposals³⁵: the SEEA, Unpaid Ecological Costs and the CARE model. The SEEA is essential in the field of environmental

³⁴ https://ec.europa.eu/environment/biodiversity/business/align/index_en.htm

³⁵ Two other approaches have inspired us, although we have not used them fully in this thesis: the work of Jean-Louis Weber, who developed the ENCA, and the *Environmental sustainability gap* (ESGAP). The latter is not

national accounting, as a large part of this system is the international standard that statisticians must follow. There is still room for manoeuvre when it comes to ecosystem accounts, the biophysical part of which has been the subject of an initial standard since 2021. But the monetary part is just a set of recommendations at this stage. Furthermore, Unpaid Ecological Costs (at national level) and the CARE model (at company level) are relatively convergent and are so-called strong sustainability models. We describe them in more detail here.

3.2.2.1. The SEEA, an environmental and economic NC standard

The System of Environmental-Economic Accounting (SEEA) is an information system based on national accounting conventions. It is designed to measure the state of the environment and its relationship with a nation's economy.

It is the result of a global initiative led by the National accounting community in developed countries. The United Nations Statistical Commission serves as the Permanent Secretary of the main decision-making body for the SEEA. Other international organisations such as the Organisation for Economic Co-operation and Development (OECD), the World Bank and Eurostat were actively involved in the creation of this standard. For more than 30 years, meetings were organised to share ideas and feedback from national experiences and gradually reach a consensus on the conventions for building this information system. There have been four key stages along the way, represented by the publication of manuals. Initially conceived as state of the art, some of them became international statistical standards after 2012.

The various versions of the SEEA focus on all aspects of the environment: pollution, renewable and non-renewable natural resources (e.g. water, forests, fisheries and minerals), land and, most recently, ecosystems. Certain sub-sections are devoted to climate change and biodiversity. Both physical and monetary accounts and indicators are presented. Several approaches are proposed: flow approaches, broken down into footprints and input-output approaches; capital approaches (measurement of stocks recorded in balance sheets), which bring together the measurement of natural assets and degradation, resource depletion and Ecosystem services; and economic responses such as protection expenditure, taxes and subsidies or environmental goods and services. (Radermacher, 2020, p. 106). Initially designed to correct GDP, and thus modify economic national accounting, the SEEA quickly became a satellite system. It is still presented as such, and more as the relatively deep integration of the environment into the SNA. The criteria given by Vanoli (2005) justify this: to qualify as satellites, the accounts must be exhaustive on their subject, have internal consistency and retain a set of conventions different from those of the System of National Accounts (United Nations et al., 2009).

The first version in 1993 (United Nations, 1993a) presents a sequential approach to disaggregating the SNA accounts in order to reveal information related to the environment and to complement them with new accounts measuring environmental degradation. Its main purpose is to define a GDP adjusted by environmental degradation (a green GDP).

It focuses mainly on monetary accounts. It proposes three alternatives for measuring value degradation: measuring changes in the market value of environmental assets; calculating the maintenance costs of (theoretically) maintaining or restoring the environment, as Consumption of fixed capital; or using contingent valuation methods to further decrease the value of assets due to degradation by Households (and not only by production activities). This version clearly describes the

mentioned, but the author of this thesis contributed to an experiment to set it up in New Caledonia (Comte et al., 2021). This case study helped to advance the general thinking of the thesis, without providing results that responded as directly to the problem as those presented in chapters 4, 5 and 6.

possible changes to the national accounts, defines the concepts and methods, and gives a fictitious numerical example to understand where the new accounts fit into the sequence of economic accounts.

The SEEA 2003 (United Nations et al., 2003) aims to develop or correct the previous manual, while adding more practical experiences of account construction. One major extension concerns the physical accounts, which are much more developed than the previous version. The work on water accounts, which is the most advanced, is even the subject of a separate manual.

Long chapters are devoted to the subject of monetary valuations of environmental degradation and natural resource depletion. Three approaches are described. Two of them have microeconomic roots and aim to adjust aggregates (damage-based approach and cost-based approach). The third method starts from the macroeconomic situation: "greened-economy modelling" models an economy that causes no environmental degradation and uses resources sustainably. The last method is an extension of the maintenance cost approach. Experiences in different countries are detailed in the handbook and alternatives are described when it has not been possible to decide in favour of one of them. However, it is difficult to find a backbone to this document, and the definitions of economic concepts are less clear than in the previous version, where they are formulated at all.

The SEEA 2012 consists of three main manuals: the Central Framework (SEEA FC), which is the statistical standard itself (United Nations et al., 2014a) the Experimental Ecosystem Accounts (SEEA ES) (United Nations et al., 2014b) and Applications and Extensions (United Nations et al., 2017).

The SEEA FC describes in detail the physical accounts of material flows, pollution, taxation, environmental activities and asset accounts (of natural resources: water, wood, minerals, etc.). On the other hand, there is only one page in this manual on the issue of environmental degradation. It is described as follows: "5.90 Degradation considers changes in the capacity of environmental assets to provide a wide range of contributions known as Ecosystem services" (United Nations et al., 2014a). In the SEEA-EEA, two pages address this issue. While the maintenance cost was of primary importance in the 1993 version, it is simply mentioned:

"6.36 At the same time, this direct [*restoration cost*] approach to estimating a possible value of ecosystem degradation resembles the approach commonly used in estimating the value of public goods in national accounts. Moreover, even if they are not used to value degradation, restoration cost estimates can still be interesting in their own right." (United Nations et al., 2014b).

There is a tiny mention of "greened-economy modelling", explaining that it falls outside the scope of National accounting. On the other hand, the valuation of Ecosystem services occupies a central place, whereas previous versions barely mentioned them. More generally, this version describes a relatively disparate set of accounts that are poorly integrated.

The third manual, SEEA WA (Applications and Extensions), looks at how summary indicators can be calculated from the accounts described in the other two manuals, and how these can be used in models.

Finally, between 2018 and 2021, another manual was produced to create a statistical standard on ecosystem accounting, called SEEA EA 2020 (SEEA Ecosystem Accounts; Committee of Experts on SEEA ES, 2021). Figure 9 describes how the accounts are structured. The biophysical accounts of extent, state and Ecosystem services are the statistical standard in their own right. Chapters 8 to 11 are international statistical recommendations only. They describe the monetary valuation of Ecosystem services and integrate it into an extended sequence of economic accounts. Degradation is defined as

the reduction in the capacity to provide Ecosystem services. Finally, Chapters 7 to 14 provide alternative approaches, including maintenance costs, and extensions.

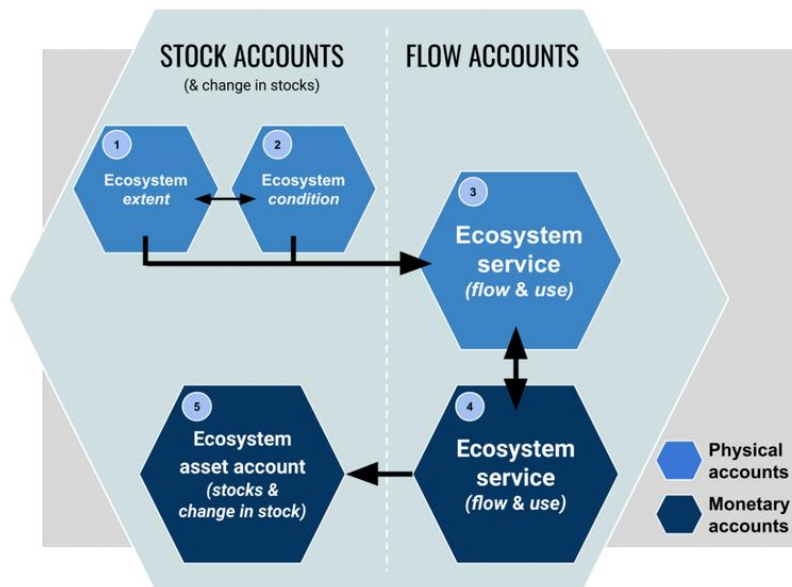


Figure 9 Relationship between the SEEA EA ecosystem accounts (source: United Nations, n.d.)

3.2.2.2. A nation's Unpaid Ecological Costs

The concept of "Unpaid Ecological Costs" is a proposed extension to National accounting put forward by the national accountant André Vanoli. It stems from a study launched in 1995 (Vanoli, 1995) the idea has been developed in subsequent publications (Vanoli, 2019b, 2017, 2015, 2012a, 2012b) which led to experiments in France (CGDD et al., 2015). The latter focused on water, climate and air quality.

For Vanoli, in contrast to the SEEA, the idea is to consider nature as a separate entity outside the economy. A separate representation of nature should therefore be designed. This would be an information system whose construction conventions would be adapted to the environment. Rather than attempting to value the whole of nature as a sum of assets, the idea would be to trace in monetary terms only the most important relationships between the economy and the environment: the depletion of natural resources and the degradation of the environment (pollution, degradation of ecosystems) at the costs of reduction and restoration. This amount would correspond to "Unpaid Ecological Costs" (UEC). It would be considered as a debt to nature, which would appear in the sequence of economic accounts as an institutional sector in its own right. This debt would not be considered as an indicator of sustainability, but of "the state of relations between the economy and nature" (Vanoli, 2019b). In addition, it would give an idea of the financing needs for the environment. L'Box 3 gives a numerical example.

Box 3: Numerical example of Unpaid Ecological Costs (source: CGDD et al., 2015)

Comptes de l'économie		
RNB		1 000
CF aux coûts payés	-	900
CENP _{CF}	-	45 [CF aux coûts totaux 945]
	=	
Épargne brute corrigée		55
FBCF aux coûts payés	-	100
CENP _{FBCF}	-	5 [FBCF aux coûts totaux 105]
	=	
Épargne négative de l'Economie		- 50
Transfert en capital de la Nature à l'Economie (= variation de la dette écologique de l'Economie) :		
CENP _{CF} + CENP _{FBCF}		50
Compte de la Nature		
(Variation de patrimoine de la Nature)		
Dégradation d'actifs naturels :	-	50
Transfert en capital à l'Economie :		50
(= variation de la dette écologique de l'Economie)		

Legend: GNI: Gross National Income, here equal to GDP by assumption; FC: Final consumption; UEC: Unpaid Ecological Costs; GFCF: Gross Fixed Capital Formation.

In this example, the UECs are 50. Environmental damage can be caused by the production or consumption of various goods and services. Here, 45 of the damage is attributable to final consumption goods and services and 5 to investment goods and services. The UECs are added to the real purchase costs of these goods and services because they should be paid for. This reduces the savings of the economy by the same amount. Vanoli considers that these costs are a loan from nature, which leads him to record a transfer of capital, and the corresponding ecological debt.

3.2.2.1. The CARE business accounting model

Comprehensive Accounting in Respect of Ecology (CARE) is an integrated business accounting model. Relationships with the environment are represented on the balance sheet by creating natural liabilities (what is owed to the environment) and natural assets (how the environment is used by the company). Among other things, placing the environment on the liabilities side makes it possible to adopt the perspective of strong sustainability (Rambaud and Chenet, 2020; Rambaud and Feger, 2019; Rambaud and Richard, 2015; Rambaud, 2015). It is fully consistent with historical cost accounting and takes up its foundations. In this way, the historical concept of capital as an external asset used by the company and which must be repaid is extended to the environment. This model is designed in response to the many environmental extensions of accounting based on another model, which sees capital as something intrinsically productive. The environment is then only a source of value, and the only thing to be preserved is this flow, regardless of the underlying ecological entities (see the publications cited above and Chapter 2 of this thesis for a more detailed presentation and discussion of the differences).

The two models differ fundamentally in their objectives. Model 1, which has been the historical paradigm of how business has operated since the Italian merchants of the Renaissance, and which is still widely used in business and entrepreneurship, focuses on the following question: "What have managers done with the funds entrusted to them? (Rambaud and Chenet, 2020). The model 2

paradigm, which emerged in the 1960s under the growing influence of financial players and neoclassical economic theory, is centred around the question: "What do managers hope to get in return? Thus, the main addressees of accounting based on model 1 are the company's managers, with a view to accountability for the company's activities. Model 2, on the other hand, is primarily intended to inform owner-shareholders about the value they can derive from the company (particularly in the short term).

According to model 1, the company is an entity in its own right, existing independently of the capital provided and its owners (Figure 10). The notion of capital is understood as money to be repaid (and not productive money, or productive things). This is made available to the company, which results in the corresponding amount being entered as an asset (in the bank account). The capital is thus degraded, as it loses liquidity (arrow 1). These contributions are then used by the company as part of its business model: purchase of fixed assets, raw materials, etc. with a view to combining them to produce goods or services for sale (2). The value that leaves the company, i.e. that is consumed in production, appears as expenses (3). These include depreciation and other current expenses. Sales (4) generate income which is primarily used to repay capital (5) (this is intuitive in the case of supplier debts, but it is in fact the case for all liabilities, including long-term liabilities, which are virtually repaid and reinvested each year). The surplus after this repayment is profit, which can be distributed or reinvested in the company.

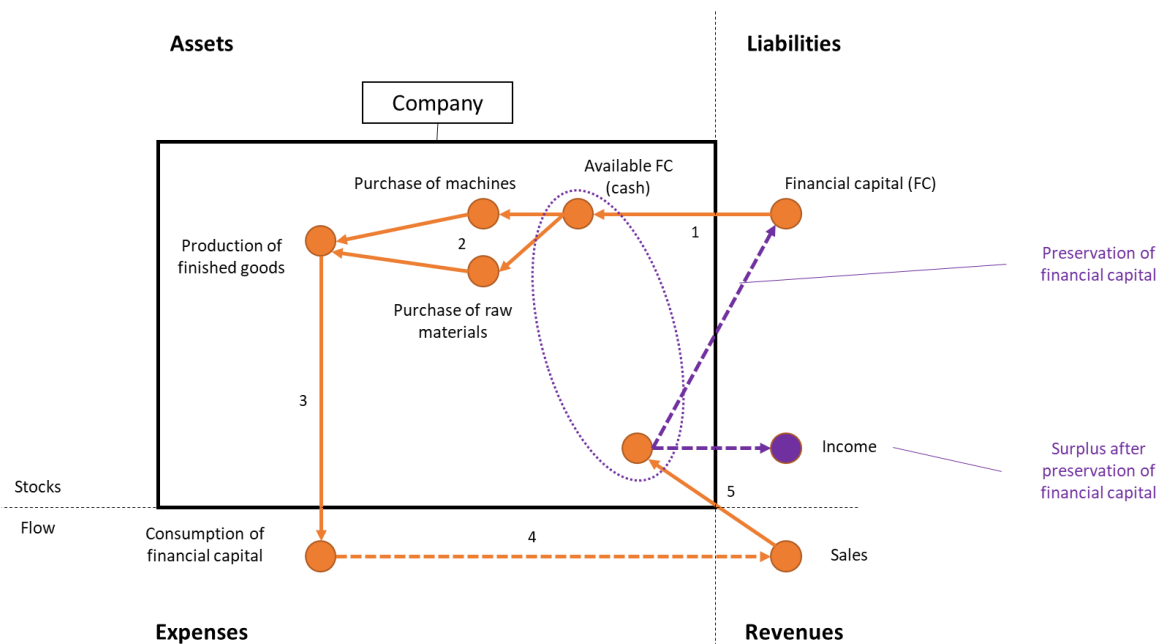


Figure 10 The conception of capital and the firm according to model 1 (source: Rambaud and Chenet, 2021; Rambaud and Feger, 2019)

The whole purpose of the CARE model is to extend this logic to new capitals, which are also subject to preservation concerns (Figure 11). We can thus define environmental capital (which will be studied and discussed at length in this thesis) and human capital. In this case, we consider that non-financial capital is independent and external to the company, and is made available to it. The assets represent the uses of the capital provided and are combined with the "traditional" assets to generate production. Sales revenue is used to repay and maintain all the capital. What remains can then be distributed.

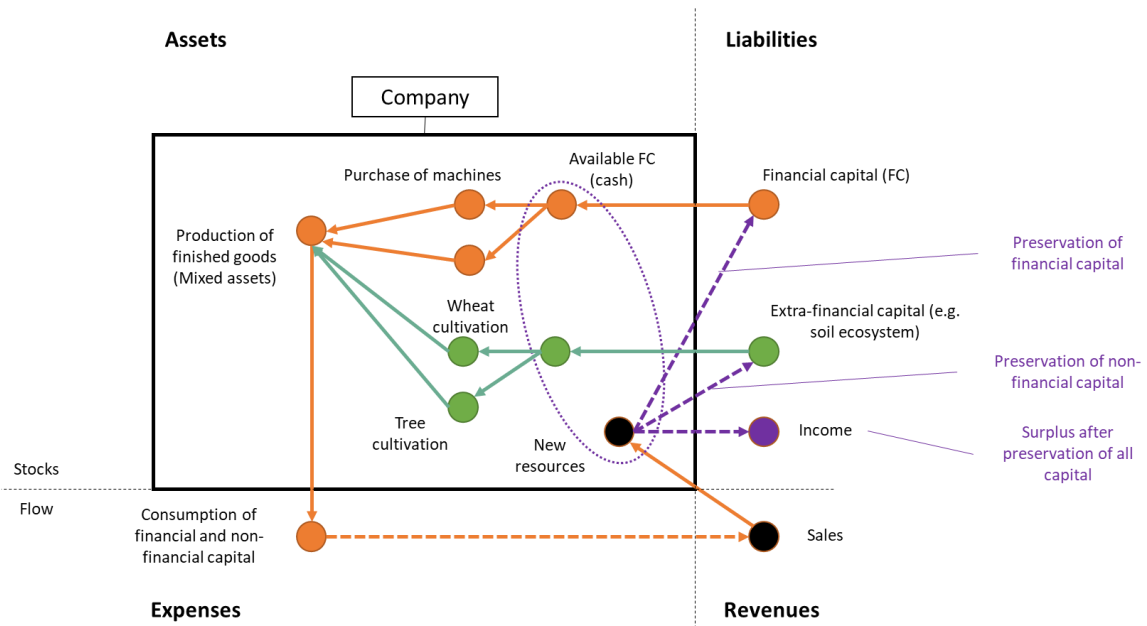


Figure 11 The environmental extension of Model 1 accounting (source: Rambaud and Chenet, 2021; Rambaud and Feger, 2019)

Non-financial capital has its own nature, which is not primarily expressed in monetary terms. Climate capital can thus be defined by one of its characteristics, its concentration of greenhouse gases, and human capital by its physical integrity. It is in these terms that these capitals must be preserved. That said, it is possible to translate and convert these indicators into monetary terms by estimating the costs of preserving these entities (reducing the impacts associated with a particular use, or restoring it). Thus, to be considered as capital, an entity must satisfy several conditions: it must actually be used by the business model, it must be the subject of a shared concern for preservation, at least by one stakeholder, and there must be at least one way of preserving it. This last condition excludes the need for accounting management of irreversible impacts, which lend themselves instead, for example, to upstream protective regulation.

The concretisation of this in the balance sheet and income statement is presented in Table 3 and in Table 4. In particular, we can see the structuring according to the operating (production) and preservation cycles and, within the former, the separation of issues relating to financial, human and natural capital. In the part reserved for the preservation cycle, liabilities specifically earmarked for preservation may appear. Opposite, the fixed assets linked to these activities.

Table 3 Balance sheet structure according to the CARE model (source: adapted from Rambaud and Chenet, 2021)

Balance sheet - CARE			
FINANCIAL ISSUES			
Financial assets	Amount	Amount	Financial capital
Investments			Equity
Current assets			Debts
Cash			
HUMAN ISSUES			
Human assets	Amount	Amount	Human capital
Investments (e.g. permanent employment)			Employees (with profit-sharing)
Current assets (e.g. fixed term work)			Employees (without profit-sharing)
Available human capital			
NATURAL ISSUES			
Natural assets	Amount	Amount	Natural capital
Investments (e.g. tree farming)			Soil
Current assets (e.g. wheat crop)			Ecosystem
Available natural capital			Climate
Preservation of capital			
Preservation assets	Amount	Amount	Preservation liabilities
Investments (e.g. wastewater treatment plant)			Debts / grants / capital preservation obligations
Current assets			
New resources from customers (e.g. sales receipts)			
Result			
Total Assets			Total Liabilities

We can see that certain items that already exist in the financial accounts have been reclassified: in the income statement, salaries are split between expenses for preserving and accessing capital. The latter category corresponds to expenditure incurred in raising and making available capital. Financial income and expenses appear in a new category called access to capital. This functional breakdown makes it possible to isolate expenditure and income strictly related to the search for and acquisition of capital.

Table 4 Structure of the income statement according to the CARE model (source: adapted from Rambaud and Chenet, 2021)

Income statement - CARE			
OPERATIONS			
Operating expenses	Amount	Amount	Operating income
Expenses on financial capital			Sales
<i>Current expenses (e.g. purchases of stocks)</i>			Stocked production
<i>Depreciation and amortization</i>			
Expenses on human capital			
<i>Circulating expenses</i>			
<i>Depreciation and amortization</i>			
Expenses on natural capital			
<i>Circulating expenses</i>			
<i>Depreciation and amortization</i>			
CONSERVATION ACTIVITIES			
Preservation charges	Amount	Amount	Preservation revenues
Soil			Prevention
Ecosystems			Restoration
Climate			
ACCESS TO CAPITAL			
Charges	Amount	Amount	Products
Traditional financial expenses			Traditional financial revenue
Expenses for accessing human capital			Revenu from the provision of access to human capital
Expenses for accessing natural capital			Revenu from the provision of access to natural capital
EXCEPTIONAL			
Exceptional expenses	Amount	Amount	Extraordinary income
Total expenses			Total Products

3.3. General governance issues surrounding the integration of the environment into NA

The governance of national management of environmental issues can be illustrated as follows Figure 12. To date, environmental information systems are still conceived as satellite tools, maintaining partial connections with the NA and economic statistics. There are relatively routine users of these data, chief among them the Ministère de la Transition écologique and the agencies under its authority. This feeds into the development of environmental public policy. That said, in the absence of a fully common language, integration with economic issues is not easy. At the same time, these environmental players have almost always been left on the sidelines of the "integrating" administrations, which arbitrate between ministerial dossiers and set the broad policy directions (Presidency, Prime Minister, planning body, Ministry of Finance, etc.).

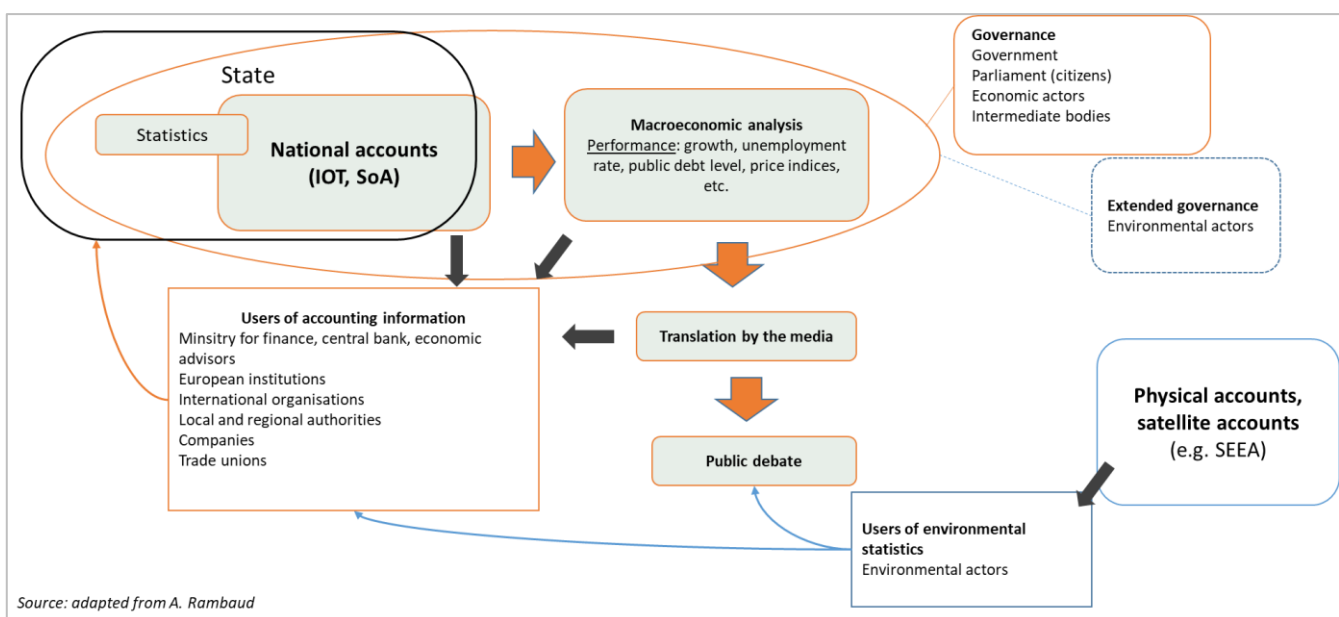


Figure 12 A world where economic and environmental issues are disconnected

The whole point of accounting integration is to bring environmental stakeholders closer to the decision-making process, at least in terms of language and representation. This would be a first step towards transforming the system of governance, which the BA has been calling for. Figure 13 provides an illustration³⁶. The players responsible for national environmental issues would become institutional users of economic and environmental information, while the traditional users of the NA would see new issues emerge, along with their effects on the objects they already manage (risks, opportunities, impacts, etc. on growth, unemployment, public debt).

³⁶ Of course, there are other considerations involved in modifying the governance of public policies: the prioritisation of issues by citizens and heads of state, the balance of power between players and administrations, budgets, etc.

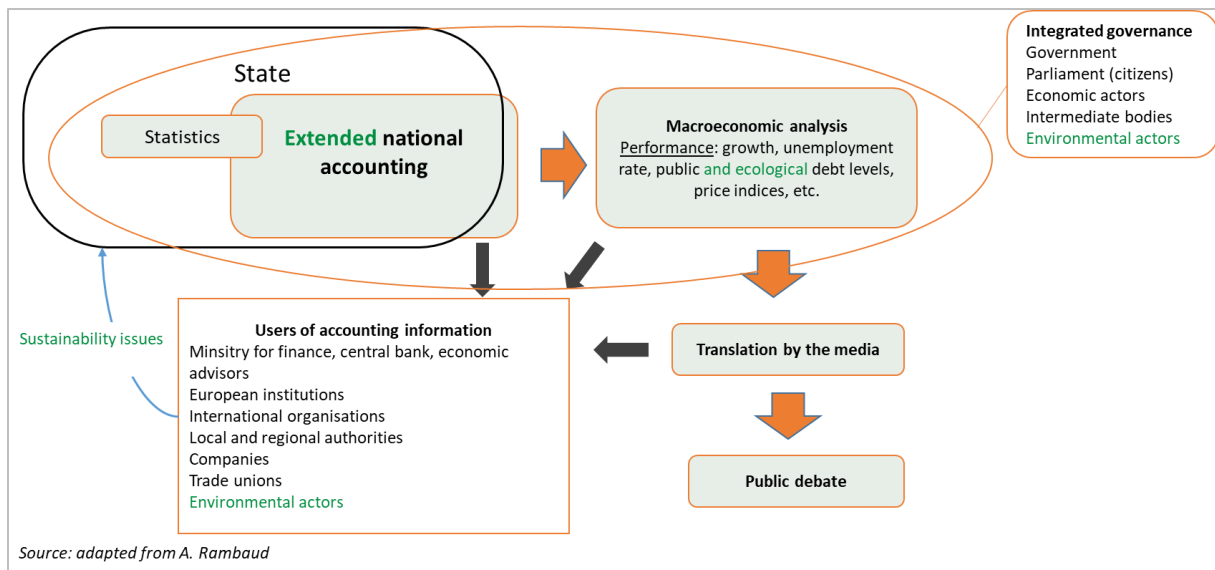


Figure 13 Towards the integration of economic and environmental sustainability issues

As regards the production of information, the separation between statistical services and public policy design and evaluation services, which has made it possible to increase the realism of the values produced and greater stability in the production of the latter, has also led to increasing difficulties in changing the accounting system when its usefulness has been weakened. The Commission nationale de l'information statistique (CNIS) maintains a link between producers and users and facilitates the transmission of new requests (the CNIS sometimes discusses environmental issues). But the lack of integration between departments, under a common management, is probably an obstacle to moving towards ambitious transformations in this area.

Environmental statistics are no exception. This separation of users and producers is a legacy that seems to be little questioned, despite the difficulties it creates for initiating forms of ecological transition. The players we met and the authors are often looking for a model of statistical purity, whereas we are still very much in a phase of flux that requires ongoing dialogue between users, designers and producers. This is particularly noticeable in the (sometimes blocking) quality requirements of experts from national statistical institutes. To manage this tension, it would certainly be appropriate for the new accounting proposals to follow several stages. Starting with public policy evaluation departments or agencies responsible for managing environmental issues (ADEME, Office Français pour la Biodiversité, Water Agencies, etc.), which are less constrained in terms of innovation and the quality of the data produced, these proto-accounts could gradually move towards production by statistical bodies.

3.4. Around the SEEA, uncertain models of action

3.4.1. A long way to go in analysing the links between concepts and uses of environmental accounts

The European Court of Auditors has carried out an audit of the European economic accounts for the environment and has pointed out that they were constructed without the European Commission clearly expressing its needs for the data and indicators required for public policies (European Court of Auditors, 2019). In addition, only assessments of the cost of these policies have been produced (including the availability of data), but not of the benefits expected from their implementation. The Court of Auditors adds that certain accounts are regularly used (material flows, environmental

protection expenditure and environmental goods and services accounts), but that environmental tax accounts are not broken down in a relevant manner. Atmospheric emissions accounts and physical energy flows have not been used to design or monitor the public policies taken into account in the audit.

Surprisingly few studies have been carried out on the potential uses of environmental accounts. In their systematic review, Comte et al (2022) identify only 45 articles out of 378 that explicitly address the issue of matching accounting to public policy needs. 40 of these were published after SEEA 2012, making it a recent topic. This is largely due to the lack of representation of potential users at the SEEA. Only statisticians and National accounting (the producers) are responsible for setting international standards.

Before 2012, the few sessions of the UNCEEA or the London Group dealing with the question of users were entitled, rather revealingly, "*promotion of environmental-economic accounts*" (UNSD, 2007). The aim was to identify "*possible vehicles for promoting the use of the accounts and make users aware of the usefulness of environmental-economic accounts data*" (ib.). Even more clearly, a presentation given at the 10^e London Group was entitled "*How to 'educate' the users to the potential of using environmental accounts*" (Costantino, 2006). The separation between designers and users is quite radical.

Reflections on the subject matured considerably after 2013. As we have seen above, there is the idea that it is the accounting policies that may sometimes be inadequate or that they should be discussed directly with users (Recuero Virto et al., 2018; Ruijs et al., 2019, 2019). Thus, to overcome the lack of involvement of potential users in the development of the SEEA, Vardon et al. (2016) propose to involve them much more in the future by having a "greater focus on end uses in the design of accounts". This would involve, in particular, "the systematic evaluation of past and potential uses of the accounts" (ib.) and "an in-depth understanding of the purposes and objectives of environmental policies" (ib.). This leads these authors to draw on the connection between the accounts and the phases of the public policy cycle described in the BA. Figure 14 (Vardon et al., 2016). Discussion forums³⁷ have been set up to make progress on these issues as part of the WAVES programme, supported by the World Bank from 2016.

³⁷ Named *Policy Forum on Natural Capital Accounting for Better Decision Making*.

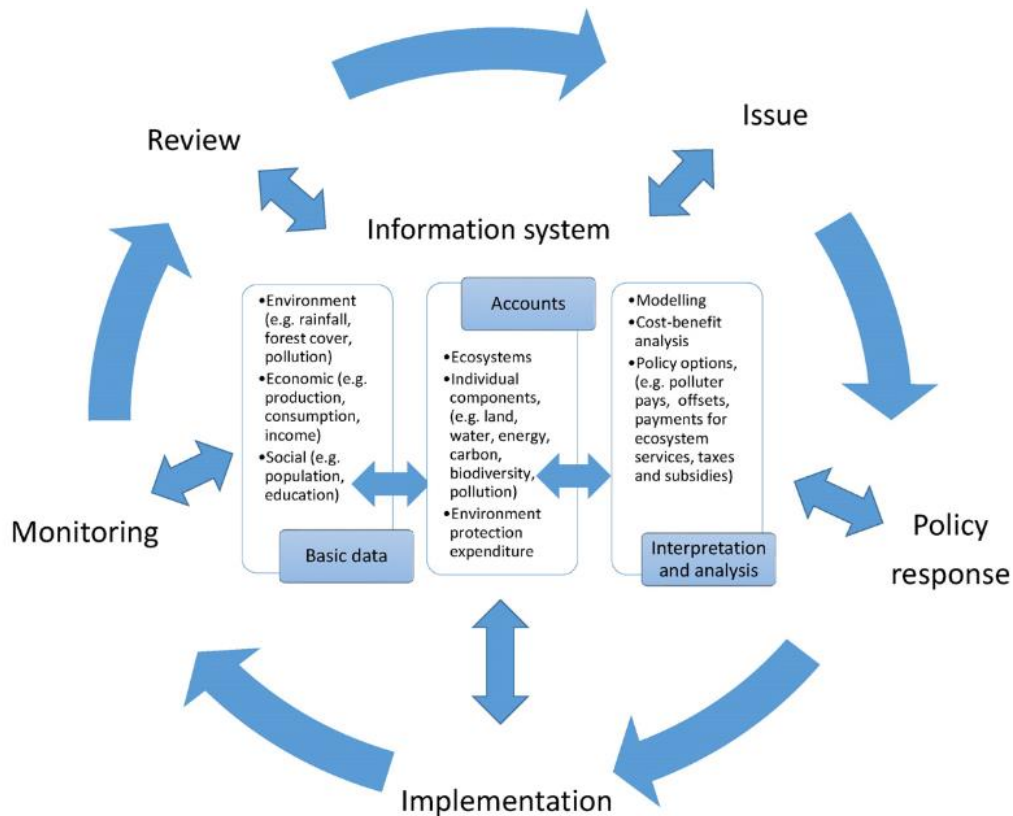


Figure 14 The place of environmental accounts in the information system and the policy cycle (source: Vardon et al., 2016)

These phases seem to us to be important points of reference and analysis, and relatively indispensable as a first approach. However, they also seem to us to lack relief insofar as it is easy to imagine that any form of accounting can potentially be useful in each of the phases (this is moreover what emerges from subsequent work: see in particular Ruijs et al., 2019). The question that seems important to us is rather to know whether or not, and how, this or that account or convention is adapted to only certain modes of 'issue identification', 'policy response', 'implementation', 'monitoring' and 'review'. There are several possibilities for each phase. Similarly, it is more or less easy to connect these agreements to fiscal instruments, to law (regulations of all kinds such as obligations and prohibitions, prudential rules, protection zones, etc.), or to spatial or economic planning. The same applies to the other phases. It therefore seems more relevant to us to seek to distinguish the contribution and limitations of certain conventions in given contexts, rather than to promote an accounting system by showing that it serves as many cases as possible.

To highlight the lack of user take-up, let's look at the various obstacles and favourable conditions that have been identified in the SEEA literature.

3.4.2. The design of environmental accounts is crucial to their future use

Several authors indicate that the disconnection between producers and users is problematic and that it is a factor explaining the (very) slow implementation of environmental accounts (Bagstad et al., 2021; Comte et al., 2022; Recuero Virto et al., 2018; Vardon et al., 2016). The articles cited point to a problem of demand ("accounting pull" from Vardon et al. (2016)), or a mismatch between accounting design choices and public policy needs. In these studies, this problem is the first or second biggest obstacle

identified. Ministries and potential users are much more aware of this obstacle than statistical institutes (Recuero Virto et al., 2018).

There are other factors that explain the low take-up of accounts. We cite those identified as the most important by the survey by Recuero Virto et al (2018) and the feedback from Ruijs et al (2019).

Institutional or political issues are often present: the lack of support at the highest decision-making level is thus the first blocking factor identified in the survey conducted by Recuero Virto et al (2018). The same importance is given to the lack of leadership to promote the use of accounts by other ministries. Lack of cooperation between institutions comes next (due to different administrative cultures, data confidentiality, etc.). Countries with long experience of environmental accounting rely on institutions that are responsible for making these links: the most advanced case is the *UK Natural Capital Committee*, which reviews the accounts and makes recommendations to which the Treasury must respond. Sweden and the Netherlands have also succeeded in building lasting links between producers and users in the same way (Ruijs et al., 2019, p. 720).

In the same vein, but a relatively less important factor, Ruijs et al (2019) identify the trust that users place in the data produced as a brake or facilitating factor. This covers the separation of roles between producers and users, which is supposed to ensure neutrality in the accounts. But in some countries (Guatemala, Indonesia, Botswana, Colombia), this is not seen as a problem. Data quality, on the other hand, is a universally recognised factor. The lack of data or its poor quality is another obvious aspect (Ruijs et al., 2019; Vardon et al., 2016). In the survey by Recuero Virto et al. (2018)(2018), this criterion came after the political, institutional and account design issues mentioned above. In fact, it is a factor put forward much more by the statistical institutes than by the ministries. Bagstad et al (2021) and Recuero Virto et al (2018) seem to obtain contradictory results on data quality. The former point out that this is a stronger brake in countries that are well endowed with data (in the economic field, or on environmental themes that are already well established), which is often the case in countries with higher incomes. This is explained by a requirement for quality that is directly very important for any new subject. They explain that this problem is less of an issue in countries that are used to working with lower quality data or models that include more assumptions. On the contrary, the Recuero Virto et al (2018) shows that the lack of data is a much greater obstacle in low-income countries. In reality, these are two different problems: in the first study, it is more a question of confidence in the numbers, while in the second the obstacle in question is the simple absence of data, which necessarily blocks statistical construction.

The relative novelty and complexity of the concepts, particularly as regards ecosystem accounts, are sometimes given as the reason for the delay in developing environmental accounts (Vardon et al., 2016). Although this factor sometimes appears, we would like to express our doubts as to its importance. Both General Government and politicians are used to managing complex concepts in an open decision-making and action environment. Getting to grips with new accounts, even if it takes some time, does not seem to us to be a structurally blocking factor. With regard to the relative novelty of the concepts, it should be noted that in some countries, notably France and Germany, this aspect is more the result of forgetting (almost completely in France or partially in Germany) the work done in the 1980s (Commission interministérielle des comptes du patrimoine naturel et al., 1986; Statistics Canada, 1994). That said, it is true that the 1992 Convention on Biological Diversity was not enough to create a general momentum around biodiversity. Economic and social interest in this issue remained lukewarm until the publication of the Millennium Ecosystem Assessment (2003).

Despite their interest, it seems to us that future work on the potential uses of the SEEA would benefit from 1° extending the coverage of the accounting conventions studied, 2° refining the theories on the mobilisation of information in policy frameworks, and 3° better understanding the links between the maturity of ecological issues and accounting. We will discuss these three aspects in turn.

3.4.1. First reframing: study *all* accounting policies in the light of current practice

With regard to the accounting conventions examined in the studies cited above, it can be noted that they most often concern the choice of modules to be implemented first (or already implemented), or the way in which the information is formatted in order to present it to decision-makers. This corresponding to the idea that users should "shape the purpose/focus of natural capital accounting" (Bass et al., 2017) that is, only the most general and visible elements. The rest seems to be in the technical domain, that of National accounting³⁸. However, Vardon et al (2016) refer to "the design and structure of the accounts themselves". But the examples they give in their article are the choice of statistical unit (perimeter of ecosystems, species selected, etc.) or the synthetic indicators that can be derived from the accounts. In addition to the indicators, they also talk about the re-formatting of data from the accounts, their translation and use in analytical frameworks (e.g. cost-benefit analyses, introduction into models) and interpretation (creation of time series, panels, comparison with theories, etc.), which are often considered to be uses in the strict sense of the term (Figure 14 See also, for example, Ruijs et al., 2018, p. 25).

These ideas are echoed in articles that seek to identify the possible connection between the accounts produced and national strategies, objectives, or phases in the public policy cycle (Figure 14) (European Environment Agency, 2019; Ruijs et al., 2019; Smith, 2014; Vardon et al., 2018). Most of the time, it is just a matter of seeing the presence or absence of an account and therefore the potential connection or contribution to a plan or phase of the policy cycle.

Other analyses of the links between technical conventions and the use of accounting tools focus on accuracy, timeliness, accessibility, interpretability and consistency, which are the classic statistical quality criteria (Vardon et al., 2018, 2016). Producers must therefore pay particular attention to these criteria, even if trade-offs often have to be made between them (Vardon et al., 2018).

We also note that usage is analysed for the SEEA Central Framework accounts (i.e. the resource, flow and environmental activity accounts). This is quite natural, as these are the most widely used accounts. On the other hand, we might have expected some theoretical reflections on ecosystem accounts, but these are hard to find.

We think it's a pity that the discussion did not include elements that we feel are more structuring. These include the following:

- The choice of unit of account: monetary or biophysical,
- To show the environment as an asset or liability,
- The choice of ecosystem status indicators and desirable reference thresholds,
- The structure of typologies: of Ecosystem services, of assets, of entities to be preserved, of preservation activities, etc.

³⁸ This is entirely in line with a realistic vision of quantified objects and a use of proof, rather than coordination (Chiapello and Desrosières, 2006a).

- The framework for monetary valuation: definition of degradation, valuation method, etc.
- Or again, the level of integration with the economic accounts: none, satellisation, articulation, full integration.

These elements are much more important for users. They involve particular models of action and cosmologies that have very important implications for the environmental outcomes that can result from the use of accounting (Feger, 2016; Feger et al., 2018; Rambaud, 2015). If we take a more constructivist view of public problems, we can see that these accounting choices are closely linked to the way in which the environmental problem is defined: is it a biophysical problem or a problem of perceived values? Is it a problem of lost economic benefits (opportunity cost) or of additional expenditure?

It is possible that these points are not mentioned because some of them were the subject of heated debate during the first twenty years of the SEEA. Since the adoption of the new statistical standard has made it possible to settle some of these debates (or to leave some aside), there is probably no question for the authors cited above of reopening these black boxes. In this thesis, however, we propose to study these points, because they seem to us to be essential in guiding the decisions that can be made using accounting. We will attempt to advance certain debates that have taken place within the SEEA by connecting the various proposals with theoretical elements and models of action.

3.4.2. Second reframing: enriching the theories of action

3.4.2.1. *Relatively implicit theories of action that can be reinforced*

Feger (2016, pp. 126-129) describes how the designers of information systems for the environment generally conceive (most often implicitly) the mobilisation of their tool in real action contexts.

The first is the **rational model** model (Sen, 1995) according to which a decision-maker acts accordingly as soon as he has all the information. In this case, the designer of the information system must produce the most reliable information possible, by:

"providing scientifically robust information on the importance of preserving ecosystems, refining models to better quantify the trade-offs between different planning or management choices, revealing invisible values, helping decision-makers prioritise their preferences, or offering optimisation calculations" (Feger, 2016, p. 127).

This is the model implicit in the proposals of Vardon et al (2016) *Thus, environmental accounts and the reports derived from them should be designed to provide the most decision-relevant information in the most usable format to those making the decisions*". Traces of this can also be found in past SEEA discussions, in the idea that a monetary value would act as a "*silver bullet*" for political and financial decision-makers. The idea that monetary information would be decisive has now been strongly relativised (Bass et al., 2017; Committee of Experts on SEEA ES, 2021)..

Feger points out that rationalisation efforts are essential in complex situations due to the number of players involved, the nature of the environmental problems to be managed, the lack of information and the often conflicting nature of the situations. However, this model is limited by the fact that there is not always a clearly identified decision-maker "in charge". Instead, there is often a diversity of players in conflict. Nor are potential decision-makers always rational (i.e. with an accurate view of their needs and preferences and the means of satisfying them, able to obtain and organise a large amount of ethical, technical, economic, strategic and feasibility information, etc.). (Sen, 1995). Finally,

"rationality itself is limited and overwhelmed by reality" (Feger, 2016). When there is a strong actor, such as a state, it often appears that rationality is not as clear-cut as the books say. Instead, decision-makers follow a tangled hierarchy of objectives and values that reflect those of society more or less faithfully (Godard, 2004, 1993).

The second approach is called **"as is"**. In this case, the designer of the accounts seeks to identify the contexts for action (institutions, relations between players, existing desire for conservation, etc.) which are favourable to the effective and efficient use of the accounts and which will lead to a change beneficial to the environment. The authors then list the favourable factors, explaining that the proposed tool has limitations or that it can only be used as a complement to other approaches. For them, there is no question of acting on the organisational or institutional aspects, which are given. Identifying favourable and unfavourable factors is of course essential to arming oneself against difficult situations, but such an approach leads to excluding all unfavourable situations from consideration.

Chen et al (2020) provide a good example of an analysis using this implicit decision model. The authors compare the institutional and organisational situations in which these accounts can be usefully mobilised. On the basis of three case studies in Norway and some theoretical considerations, they conclude that the SEEA is most likely to be adopted and fully used in stable institutional situations, where the players defending species conservation have a relatively central position and where relations with ecosystems are recognised as strong (e.g. protection or integrated management zones). In cases where conservation issues are less integrated into the most important policies of the context in question (they give the example of kelp harvesting areas), the SEEA may be of interest, but essentially on resource management issues. Finally, in cases where several activities interact around the same ecosystem without any institutional connection (e.g. fishing and coastal aquaculture), accounting may have a role to play in facilitating interactions and coordinating them.

Another example is given by the findings of the studies cited above that identify factors favourable to the implementation of SEEA accounts. Vardon et al (2016) also use this model:

"It will also be important to understand when information is more or less likely to influence decisions, to better understand the political as well as the environmental relevance of information."

The third model is the **participatory model**. In response to the limitations of the previous two models, it is sometimes argued that the process of building information systems and the involvement of stakeholders is just as important as the technical aspects. By taking into account a diversity of viewpoints, it is possible to improve stakeholder involvement from the outset, to interest them and to create a tool that reflects their concerns. This decision-making model can usefully create a common language, integrate existing knowledge and tools, and lead to collective learning. But, like any participatory process, it can also mask key strategic dimensions, hide or evade conflicts or power asymmetries, or reproduce situations that have already reached a deadlock. A fully participatory model implies mobilising all the stakeholders involved in the environment, including those who have an impact on it or who do not particularly want to see it improved (or at least arbitrate against it). (Mermet, 2011; Mermet et al., 2014).

The SEEA has partially integrated this point of view, but in a restricted version: forums of natural capital experts or potential users have been created. But they essentially bring together voluntary players

who are more or less keen to preserve the environment. In reality, this model is hardly ever used in the context of National accounting. We see several fundamental reasons for this. The first is that the international standardisation of economic NA is a process historically led by the statistical services of international institutions (the United Nations, the IMF, the OECD, the World Bank and the European Commission). In the case of environmental NA, it is carried out by the statisticians of the member countries and, to a lesser extent, by the international institutions (in addition to the FAO). This automatically rules out the direct involvement of 'decision-makers' and other users. A second aspect that seems central to us is the requirement for neutrality and quality on the part of statistical offices. The criterion of neutrality in particular imposes a severe filter on the inclusion of overly explicit political dimensions.

3.4.2.2. *Our positioning: a contextual, negotiated and strategic approach to accounting*

At national level, we find similar conclusions to those of Feger (2016) who studied management and balance sheet tools³⁹ at company or regional level. He indicates that the theoretical frameworks used are simplistic and do not stem from the accounting discipline, through its critical and interpretative branch⁴⁰. In our case, the article by Chen et al (2020) is a very good example (and the only one to our knowledge) of extensive mobilisation of literature in accounting and sociology. The authors could have gone further than these three models, but they do not really go beyond the 'as is' model, certainly because of the balance sheet nature of NA and its standardisation, which prevents it from fully considering the question of uses.

Although he was working on management accounting, we propose to adopt the same point of view as Feger (2016) when it comes to discussing the choice of conventions. This seems to us entirely possible and relevant for the NA. Indeed, the first part of this chapter enabled us to conclude that standardisation emerged after long phases of co-construction of information systems with action doctrines. For a long time, NA seemed to fall into the category of management accounting, before gradually being standardised. As far as environmental NA is concerned, the still lively debates that may be taking place show that things have not yet stabilised in many respects, including the action doctrines to be backed up.

The first step, therefore, is to think about them in the light of the diagram described at the beginning of this chapter. In particular, it is essential to consider the accounting system in a specific **context**. **The purpose of** NA standardisation is to make the accounts produced by different countries comparable for given purposes: international comparisons, submission of accounts on the state of the economy (and income) with a view to contributing to supranational budgets or receiving funds. If such uses are indeed central to environmental management, we believe it is entirely appropriate to undertake this harmonisation work. On the other hand, if there are conventions that are more useful for environmental management at national level (via national public policies), the question arises as to

³⁹ The aim of *balance sheet accounting* is to "produce a standardised overall picture of the situation, assets and performance of an organisation as a whole on a regular basis, in order to report to its external stakeholders (economic and social players, investors, public authorities, etc.) for evaluation purposes" (Feger and Mermet, 2021a). *Management accounting*, on the other hand, is "non-regulated and ad-hoc accounting, the main purpose of which is to help managers within organisations (at the level of a project, a team, a division of activity, etc.) to formulate and implement strategies, and to analyse, decide, manage, plan and control activities, costs, resources, performance and responsibilities linked to the formation of results and their variations" (ib.).

⁴⁰ This shift in viewpoint is similar to that observed in political science, particularly by French authors (Monnier, 1991; Muller, 2018, 2005) the rejection of purely rational, bureaucratic and techno-economic optimisation models in favour of pluralist models.

which user should be favoured (international or national?). If so, which national administration?) This tension could arise in the case of EU member countries, as environmental policies are the joint responsibility of the Member States and the Union. In both these cases, and all the more so if we extend the reflection to all the countries of the world, these national or European 'governments' have an organisation, a functioning and relations with society that are specific and not universal. The relative weight of different social, economic and environmental concerns, the type of law in place, its more or less bureaucratic or technocratic nature (seeking the technico-economic optimum; Monnier, 1991)ES, its place in international organisations are all key differences that may call for specific accounting conventions.

All this raises questions about the choice or speed of standardisation of environmental accounts. However, it should be borne in mind that the integration of environmental aspects into *economic* national accounting (and not just into the environmental NA standard, the SEEA) will necessarily have to comply with standardisation, as the System of national accounts (United Nations et al., 2011) is a standardised system. One way of retaining flexibility is to consider environmental issues in satellite accounts, which adopt some of the conventions of the central standard framework, but deviate from it on certain points (Vanoli, 2002, pp. 233-239).

Secondly, in order to think about the place of information in action, it is possible to mobilise other conceptions of action in which the framing of information, and in particular of accounting systems, is **negotiated**. Once again, we should bear in mind that balance sheet accounting does not offer the same room for manoeuvre as management accounting, and does not fit into the same distribution of roles. Nevertheless, the sometimes virulent discussions within the SEEA show that there are controversies in the field and that these are resolved by confronting points of view (Feger and Mermet, 2021; see also chapter 3 of this thesis). Returning to the heart of the State, we find that public policies that mobilise indicators and quantified objectives are the subject of such debates (Bouleau et al., 2009; Bouleau and Deuffic, 2016; Canneva and Guérin-Schneider, 2011; Marchal, 2020). Our proposal is not to open up accounting standardisation to all and sundry, but to reflect on accounting conventions from a pluralist perspective and with an eye to the balance of power between the players in contact with the environment. This will make it possible to put forward proposals that can fit in with the current interplay of players, without abandoning the primary aim, which is to bring about change in favour of the environment. As in any negotiation framework, this also involves creating, or at least thinking about strengthening, one's position by modifying the context in which one finds oneself (in this case the institutional context) or actively seeking favourable points of support.

Finally, information systems need to be placed in a **strategic** perspective⁴¹. In the context of National accounting, it must be borne in mind that the State is not a single decision-maker, but that each administration, whether environmental, sectoral (agriculture, energy, etc.) or having an integrating role (finance and budget, planning, Prime Minister) has its own logic which conflicts with those of the others. This is one of the limitations of the participatory model: involving all the ministries in designing a National accounting system for the environment risks reproducing the conflicts and negotiations already underway, without leading to any substantial improvements in the way ecological issues are dealt with. The strategic perspective implies a number of refocusings (Feger, 2016; Mermet, 2011; Mermet et al., 2014). The first is to ask who is acting and driving the creation of an environmental BA: is it the Ministry of the Environment? If so, what is its scope: is it a 'militant' ministry, correcting

⁴¹ Note that a much more strategic approach than in our other readings is described by Bass et al (2017) and Ruijs et al (2019). It draws on analysis from policy science, but does not, or not fully, capture the other key elements we discuss in this chapter.

marginal problems (pollution and risk management), integrating policies that have an impact (agriculture, fisheries, forestry, energy, transport, urbanisation), or is it a planning ministry? Is it a 'leader' like the President or the Prime Minister? Or is it an institution representing more diverse interests (parliament)? It is important to bear in mind that integrating the various political issues into one large ministry or planning department does not resolve the contradictions or remove the need for arbitration. It merely displaces them within a given administration, rather than seeing them emerge in interministerial discussions. Even within a formal institution with a mandate to protect the environment, it must be possible to identify the departments and individuals who are genuinely motivated to organise all or part of their action around an accounting system. Another way of looking at things (which we will adopt) is to consider the players who are already involved in the action and who could benefit from the introduction of a new environmental accounting system.

Still from a strategic perspective, a key question is the concern that drives the environmental stakeholder(s) (and the resulting intentional management). What environmental entities does this stakeholder wish to preserve? What is the desired ecological outcome? It is not obvious that this has always been defined a priori, and that these stakeholders wish (and above all are able) to preserve the integrity of their country's entire biosphere. A selection is inevitably made, according to political, practical and other criteria. An accounting system that requires all scientifically important and measurable components to be represented will necessarily contain entities that will not be managed. As a statistical system is a cumbersome undertaking, it can be a waste of time and financial resources.

Finally, a key point in the strategic analysis of environmental management (Mermet, 2011) is the distinction between effective and intentional management. Effective management corresponds to all the decisive human actions, whether voluntary or not, whether conscious or not, whether assumed or not, that lead to the current state of the environmental entity that we wish to preserve. Based on this diagnosis, an "intentional management plan" can be drawn up. This brings together the actions planned and implemented by the environmental stakeholder to improve the state of the environment.

At the heart of this type of analysis are the notions of impact and responsibility, since these are the areas on which action needs to be taken. National accounting can be used to highlight these issues. We shall see that these can be discussed in different ways. For example, responsibilities can be understood in terms of the polluter-pays principle or in terms of a principle of socialisation of responsibility (collective assumption of responsibility). In this way, it appears that accounting can clarify actual management or reflect intentional management, depending on the purpose for which it is used. Finally, accounting can seek to represent the progress and contributions of each individual in achieving (or failing to achieve) the ecological objective.

An important aspect of our work will be to attempt to clarify and rank alternative accounting policies according to their potential contribution to virtuous action for the environment. This presupposes that not all environmental accounting conventions are equally performative, and that some may be counter-productive, despite the good intentions of their designers.

The link between the mobilisation of accounting information and changes in action or effects (actual or expected) on the environment is never described (Ruijs et al., 2018; Vardon et al., 2018). These elements of analysis are the last in the chain because they require significant investment in research, including a detailed description of the interplay of actors and institutional contexts. It was therefore expected that they would be less studied. But they are crucial, which is why we will be outlining them *as soon as we can*.

3.4.3. Third reframing: take full account of the maturity of ecological issues when designing environmental accounting.

If we take the policy cycle described in Figure 14 there are several limitations. First of all, it does not fully highlight the articulation and composition with the problems and issues already being managed (in other words, with other public, social and economic policies, etc.)⁴². The simple version of the model is based on the idea of a project or programme that is added to current management as a corrective measure, as soon as a new issue is identified (Mermet et al., 2014). This initial 'marginalist' reading of public action can be corrected by considering that the political response phase can include restructuring policies to the detriment of the environment. But this is not explicit in this model. Moreover, it still does not highlight the central role of the actors and their relationships.

Secondly, the sequence of stages seems to be carried out by a player who masters the whole process and acts without any particular resistance, in a mechanical way. It's as if the State were a perfectly oiled machine, with no resistance or transformation of policy choices by administrations and the inclusion of various and varied interests at every stage, particularly implementation. The literature in political science clearly illustrates this confrontation of stakeholder logics (Monnier, 1991; Muller, 2018).

Finally, this political cycle presupposes that the problem appears more or less suddenly as something external to the state observer. Accounting, in this context, makes it possible to realise this; it reveals the problem. In this cycle, it is precisely this visualisation tool that is lacking for the environment. This realist vision is opposed to a more constructivist idea of public problems, according to which there are struggles to get certain problems onto the political agenda rather than others (Latour, 2008; Muller, 2018).

To overcome these limitations, we propose to link the preceding reflections with the work of Bruno Latour (Feger, 2016, pp. 163-170; Latour, 2008). In the *Politics of Nature*, Latour defines political ecology, and more broadly politics, as the composition of a common world, i.e. a collective that includes new 'non-humans' over time. These can be emerging issues or challenges such as Covid, nature conservation, war, a change in the economic situation, and so on. At any given moment, the collective is made up of a network of entanglements between humans and non-humans. New entities are said to be "on call" before being gradually integrated into the collective. Their integration leads to a reorganisation of the relationships between "humans" and "non-humans" that are already in place. The composition procedure follows stages that must not be bypassed, at the risk of having to start again from scratch or of stabilising an unsatisfactory situation.

To achieve this compositional work, he invites us to move away from the separation between the study of facts (of nature in the broad sense, of our non-social environment) in the scientific domain and that of values (discussed by the social world). Latour (2008) instead proposes a joint discussion in two 'chambers' (Figure 15).

⁴² Authors working on "policy mixes" seem to draw on a similar critique. See Barton et al (2017) for a summary.

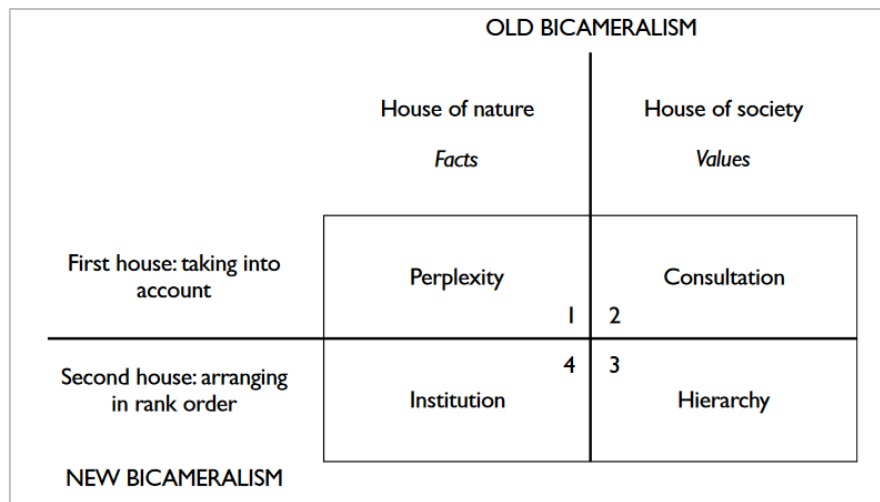


Figure 15 New separation of powers (source: Latour, 2008)

The first chamber, known as the "taking into account" chamber, sets out to "detect, make visible and make talk" the new entity under appeal. This is the "perplexity" stage. Next, it is a matter of proposing orders of arrangement and possible relationships with the rest of the collective by consulting widely with the members of the collective already constituted ("consultation" stage). The second chamber, the "ordering" chamber, aims to stabilise relationships by going through a stage of "prioritising" the new non-human with the rest of the collective, before "institutionalising" these relationships, i.e. fixing them.

During these stages, many players have a role to play: scientists, politicians, economists, and so on. Latour's new separation has the merit of showing that they have a specific role to play at every stage, but also in maintaining and challenging a collective. In contrast, the fact/value distinction led to a strict separation of roles, assigning science to facts and society to values. The role of environmental accountants, in particular, has been clarified elsewhere (Feger, 2016; Feger et al., 2017). Table 5 describes their possible contributions.

Table 5 Mobilisation of the Politics of Nature (Latour, 1999) to enrich thinking on the roles of conservation accountants (source: Feger, 2016)

Possible roles for conservation accountants (as scientists and economists)	
Perplexity	Continuously explore the boundaries of the accounting perimeter to accommodate the ongoing arrival of new ecosystem conservation issues
Consultation	Explore the multiple connections between new conservation problems and the collective entities consulted. Propose accounting summaries to report and discuss them.
Hierarchy	Propose and negotiate preference orders related to the management of a conservation problem. Find forms of commensurability and common accounting languages useful to the collective for evaluating, comparing and negotiating compromises
Institution	Set up a stabilised (but revisable) accounting monitoring system on the basis of which the distribution of responsibilities, tasks and means of collective management of a conservation problem by the members of the collective becomes possible. Develop accounting activities (control, audit, communication, animation, etc.) to help the collective monitor and manage this problem over time.

Thus, a very important point for the role of these players, but also for the tools and therefore the forms of accounting mobilised, concerns the level of maturity of the ecological issue (Feger and Mermet, 2018). Ecological issues have emerged in society at different times and with varying degrees of speed. At a given moment, therefore, they do not all have the same level of maturity. This has also been identified by others, including in relation to environmental NA. For example, Radermacher (2020, p. 102) explains that environmental metrics have followed the emergence of awareness of environmental crises in the following stages:

- "Firstly, changes in volume and price: energy crisis, (quantitative) depletion of natural resources;
- Secondly, local or regional changes in quality: air, waste, water, etc., deterioration (qualitative);
- Thirdly, global phenomena such as the ozone layer and climate change;
- Fourthly, ecosystems, biodiversity and global boundaries".⁴³

We therefore need to pay close attention to the level of maturity of each environmental issue in order to propose appropriate accounting, as not all agreements are necessarily appropriate. Figure 16 is inspired by the phases of the *Nature Policy* cycle, indicating the key issues and, below, the roles that information systems can play in advancing the consideration of the environment in decision-making at all organisational levels.

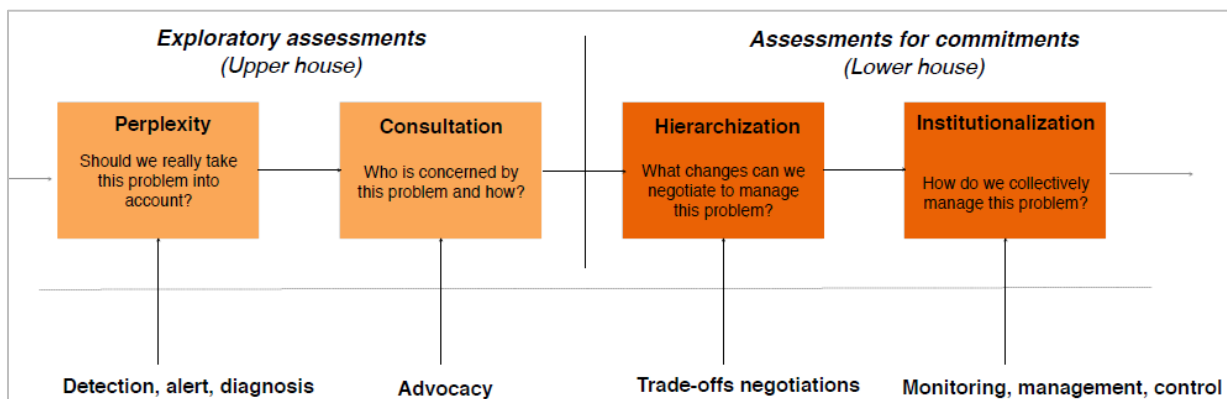


Figure 16 Maturity of environmental issues and accounting systems (source: Feger et al., 2017)

A key distinction emerges between the first two and last two phases described by Feger: the gradual transition from exploration to commitment. Thus, exploratory accounting should be able to show the various existing or potential links between the natural entity under discussion and the humans involved. On the other hand, accounting that aims to manage these relationships on a long-term basis should, in principle, contain ways of monitoring the actions and commitments of each party.

If we go back to the SEEA and Vanoli's ecological debt approach or the CARE model, we can sketch out the relationships between these models and the steps above. Thus, the monetary accounts of the

⁴³ In a similar vein, Jacques Theys (2018) distinguishes the following phases for France:

- Hygiene issues
- Pollution and industrial risks, and extraordinary nature conservation
- The pressures generated by the consumer society and the territorial changes linked to the second industrial revolution
- The emergence of global risks such as climate, biodiversity and the depletion of natural resources.

SEEA, based to date mainly on the assessment of the Net Present Value of potential ecosystem service flows, seem at first sight to be useful in highlighting the value of conserving ecosystems. Indeed, this is the motivation behind the concept of Ecosystem services (Gómez-Baggethun, 2009; Mermet et al., 2014). It has led to their monetary valuation being used in the financial calculations of investment projects (Laurans et al., 2013; Laurans and Mermet, 2014). The effects of projects on the environment thus appear in terms that are directly comparable with the financial benefits. This makes it possible to "reveal the value of nature" and provide new arguments to justify, or not, the form of a project. This was the main objective of the Chevassus-au-Louis report in France (Chevassus-au-Louis et al., 2009; Mermet and Leménager, 2015). Accounting systems that use these evaluations would be very useful in the exploratory evaluation phase.

Their mobilisation in the context of managing commitments, and therefore taking account of mature environmental issues, also seems possible, but with more limitations. In any case, it would require an additional assessment, in the form of the costs of restoring or producing these services. Attempts and proposals along these lines have been made (Gómez-Baggethun, 2009). Traces of this can be found in the Marine Strategy Framework Directive. However, the generalisation of commitment management through the prism of Ecosystem services seems questionable to us. Ecosystem services do not cover a large number of key environmental dimensions, particularly when it comes to ecological entities or functions that are protected by law (heritage species, species or functions that are not or only weakly linked to the production of a service). They neglect a wide range of values - non-instrumental and even non-anthropocentric - and thus run counter to a key recommendation of the IPBES (IPBES, 2022). In the SEEA, these values and the ecosystems that support them are considered as assets. (Committee of Experts on SEEA ES, 2021). However, this accounting category is not linked to specific legal obligations, as assets correspond to what is owned by economic players in order to store value. Regulations relating to certain assets do exist (building standards, risk management relating to plants, machinery, etc.), but they are not attached to the accounting category of asset, only to certain physical objects that are called assets in accounting. In other words, they are not included in the Commercial Code, which governs accounting, but in other legal codes.

In contrast, the concept of debt is typically an accounting category that brings together a set of obligations to third parties. It is rooted in contract law, but also contains legal obligations (provisions for decommissioning power plants and restoring mining sites). Ecological debt therefore seems much more appropriate for managing mature environmental issues, which are already the subject of legislation, clear objectives, etc. The definition of liabilities in the CARE model is based on the identification of a conservation concern shared by at least one stakeholder who can assert it. In this thesis, we rely on environmental law and in particular the major public policy frameworks, which offer a clear indicator of social concern about ecological entities or functions. This reflects a concern shared by citizens within a country, and expressed through a democratic process. Moreover, the State is in principle in a position to enforce these democratic decisions. On the other hand, the following question arises: is it possible to mobilise accounting frameworks that include the environment as a liability in the first two exploratory evaluation phases of the nature policy cycle? Is this simply possible and desirable? What can they contribute? Should less standardised forms of information be considered for these two phases? These questions will follow us throughout the thesis and will re-emerge in Chapter 4 in particular, and we will return to them more extensively in the general discussion of the thesis.

3.5. An ambiguous connection between accounting proposals and public policy frameworks

New information systems that are intended to be useful in achieving ecological objectives must be anchored in practices that are already in place. As Feger (2016) puts it:

"If they wish to play a decisive role in "the generalisation of ecosystem management" (Weber, 2014a), ecosystem balance sheet accounting would benefit from being **developed in close connection with the multitude of [information systems] on the basis of which territorial stakeholders are already organising their conservation actions**. To achieve this, ecosystem accounting and all the other [information systems] would benefit from being **discussed and negotiated** within a common framework". (Feger, 2016, p. 117)..

A reading of the SEEA ecosystem accounts shows that what already exists is sometimes recognised as important, but not always. For example, ecosystem typologies can be chosen according to the management context: *"Since there are a variety of ways in which ecosystems can be classified and compilers are encouraged to use classes relevant to their local context"* (Committee of Experts on SEEA EEA, 2021, para. 3.57). Account compilers are also encouraged to use the IUCN *Global Ecosystem Typology* for international comparisons (Committee of Experts on SEEA EEA, 2021, para. 3.54).

In other cases, however, the conventions derived from practice are left more open-ended, or even excluded. For example, ecosystem status indicators are based on scientific categories that are not necessarily linked to existing public policies (in particular the Natura 2000, Water and Marine Environment Directives, which are particularly important in Europe). The criteria used to select the state variables do not, under any circumstances, include socio-political considerations or considerations linked to past management choices. The first two criteria are "intrinsic relevance", which must reflect the "existing scientific understanding of ecosystem integrity", and "instrumental relevance", according to which the indicators must be "connected to the availability of Ecosystem services" (Committee of Experts on SEEA EEA, 2021, p. 114). It should be noted, however, that in practice, data availability is often a key factor for compilers of accounts. This often leads them to reuse data acquired for existing frameworks (European Environment Agency, 2019). To do so in a way that is merely roundabout seems questionable to us.

Finally, it should be noted that the logic of monetary accounts is largely disconnected from the European directives mentioned above. These directives define ecological objectives that are not linked to Ecosystem services (as in the case of the Habitats and Birds Directives), or only secondarily (only two descriptors out of eleven for the Marine Strategy Framework Directive). In addition, monetary valuations of Ecosystem services can only be used on the fringes of these policy frameworks: they can be one of the elements discussed in the context of the postponement of objectives, which can be based on cost-benefit analyses. But more often than not, it is the maintenance costs or the costs of restoration actions that are mobilised, and the cost-effectiveness analysis framework is favoured (Feuillette et al., 2004)(Feuillette et al., 2016; Levrel et al., 2014a).

These choices can be interpreted in the light of the authors involved in drafting the standards. As we have seen, historically few or no users have been involved, even if some considerations from them may have filtered through.

The SEEA EA initially mobilised many scientists from the ecological and natural sciences, because the experts already working on the SEEA did not have these skills (Alfieri, pers. comm., 07/05/2021). This is clearly reflected in the chapters on accounts of the extent and state of ecosystems, which include

descriptions of typologies based on the natural sciences and a list of quality criteria seeking maximum objectivity, reflecting an essentially "realistic" view of indicators, i.e. that they are supposed to measure a reality that already exists. (Chiapello and Desrosières, 2006a). The opposite, "conventionalist" position, considers that indicators help to transform the place of quantified objects in society. In this way, the observer is not strictly detached from the object, but shows it from a particular angle that changes its status. In this way, the SEEA EA accounts strongly resemble an exercise in the scientific description of ecosystems, rather than the creation of information that would be negotiated socio-politically with a view to taking action or having action taken. There seem to be good reasons for this. The relativisation of quantifications and accounting constructs is always a risk. Relying on scientific categories helps to guard against this. But the line seems too strong for us to follow the authors of the SEEA entirely. These choices restrict the possible uses of the SEEA by confining it to the use of evidence, to the detriment of uses of coordination or government. (Chiapello and Desrosières, 2006a). On the contrary, National accounting has derived its legitimacy and strength from these two types of use, mobilised jointly (Desrosières, 2014, 2008a).

Another influential category of writers are economists, to whom we shall return in detail in Chapter 3. We will come back to them in detail in Chapter 3, but it can already be said that it was they who gave rise to the ecosystem services approach in ecosystem accounts. In this case, it has more to do with a desire (ideological for some, sometimes implicit, and partly by default, as we shall see) to highlight a certain type of ecosystem management. As it happens, however, this type of management diverges from the principles enshrined in proactive European policies.

In this thesis, we will try as far as possible to take the quantification conventions that come from existing environmental public policy frameworks and 'put them into accounts'. Since these have already been negotiated politically, they have a great deal of legitimacy. This legitimacy differs from that of science, but is nonetheless particularly interesting in our view. Public policies reflect a social compromise (admittedly temporary and imperfect) around negotiated objectives, leading to the institutionalisation of the associated environmental issue (as defined by Latour). As a result, their primary strength is not necessarily to establish a diagnosis and metrics that are indisputable from a scientific point of view, but they do enable action to be triggered. And that's what we're particularly looking for. We are therefore fully in line with Mermet and Leménager (2015, p. 215):

"Another crucial element in understanding the context in which [economic tools for biodiversity] are used is to understand the institutions and management rules already in place, and to analyse the capacity of stakeholders to improve and implement them. From this institutional point of view, economic tools for biodiversity can in fact be seen as elements of rules to be added to existing arrangements, so as to enrich and improve their functioning".

Consequently, the first stage of our work consists of discussing the necessary adjustments to existing information systems and public policy indicators that follow accounting integration. This will sometimes lead us to depart from strict scientific principles, or from the metrics and accounts proposed in the SEEA. In this case, we will have to take account of the criticisms to which the conventions adopted may be exposed.

4. Conclusion

4.1. Chapter summary

The first part of this chapter has illustrated the diversity of uses of NA and how it has been co-constructed with policies and action programmes that sometimes include a renewal of the role of the state in the economy: territorial unification, estimation of national power, Keynesianism. The need to remain in a changing economic context or the emergence of new uses (international institutions) has meant that this framework has had to evolve at certain times. Sometimes profound challenges (neo-liberalisation) have not caused it to disappear, but have led to the emergence of additional, more or less convincing, information. National accounting seems to live up to its name, insofar as it mobilises the traditional functions of accounting (counting, recording in accounts, reporting, rendering accounts).

The main proposals for environmental extensions are still the subject of conceptual discussions. They aim to integrate the environment in different ways. Those we have described are based on the estimation of stocks, but with a fundamental difference: the environment can be considered solely as a set of assets, or it can appear primarily as a liability. This gives rise to fundamental debates. We shall see that these have sometimes been difficult within the SEEA (chapter 3). In our view, these difficulties stem in part from insufficient clarification of the theoretical underpinnings and related models of action. The purpose of this chapter was to clarify a number of them. Mobilising existing information systems, particularly those linked to public policy frameworks (European nature, water and marine environment directives) is a particularly important issue if we want to bring about change in the environmental situation.

A review of the literature on the potential uses of environmental NA shows that it is a fairly recent subject and that it is approached through the prism of models of action that can prove problematic. In particular, the rational model, in more or less corrected versions, is still at the heart of people's minds. We therefore propose three successive shifts in order to design national accounts that are more likely to be used. The first, which comes from the sociology of quantification, consists of analysing all the accounting conventions. The first part of the chapter illustrated that there can be many such conventions, and that they do not relate solely to the presence or absence of an account. Secondly, it is a question of following both political science and management science in order to adopt a more detailed view of the interplay of players, the strategic dimension and the way in which public policies are actually designed. As accounting is one of the elements of State policy, it is not exempt from such analysis. Finally, it is the work of Bruno Latour that will enable us to reflect on the design of accounts according to the level of maturity of environmental issues. In particular, we need to move beyond the idea that the economy-environment relationship can be fixed once and for all. By developing an accounting component for *Nature Policies*, Feger's work provides the keys to taking a further step in this direction.

4.2. Micro-macro articulation: current situation and challenges

The designers of these methods did not design national environmental accounting and business accounting together. They are distinct communities that have worked at sometimes very different times, most often without ever mentioning the systems of the other level. The micro-macro relationship thus remains little explored from either a theoretical or a practical point of view (Feger, 2016; Feger and Mermet, 2020).

The grey literature, through the London Group and the working groups around the SEEA, mentions it two or three times in thirty years, during the rare interventions of the international standard-setter for Business accounting (IFRS). Peter Bartelmus also mentions it twice, in documents that went unheeded because they were written when he left (research agenda of the 8^e London group and an article from 2014). The first recent work on National accounting is by Vardon et al (2017). At the same time, initial ideas are being gathered by the Capitals Coalition (IDEEA group, 2017; Spurgeon et al., 2018) which works at company level. The two are joining forces at the initiative of the EU and the *Natural Capital Accounting and Valuing Ecosystem Services Project* (NCAVES), of which the micro-macro link is one of the axes. A dedicated working group will be set up within the SEEA in 2020. The NCAVES project began with a report and a consultation of companies (Lammerant, 2019a, 2019b). Two case studies were then published on the subject in early 2021 (Lammerant, 2021a, 2021b). Finally, in the United States, an academic article reviews the possible contributions of national environmental accounts for businesses and the challenges of forging links (Ingram et al., 2022)..

The consultation carried out during the NCAVES project shows that there was no exchange between the micro and macro environmental accounting communities. An even more recent example is provided by the sustainability reporting standardisation exercises (within the European EFRAG or the ISSB) which did not involve national accountants. The environmental sciences that both the accounting and non-accounting communities use indirectly create similarities in the language and methods used. The result is relatively fortuitous convergence, thanks to common roots in economics or ecology. This is the case, for example, with the SEEA and the *Natural Capital Protocol* (Natural Capital Coalition, 2016) or the *Biological Diversity Protocol* (Endangered Wildlife Trust, 2020)⁴⁴ or the remarkable but completely unexpected convergence between the CARE model and Vanoli's UECs in France.

This linkage work, and the study of existing links between financial accounting and National accounting (hereafter referred to as micro-macro links), reveal mechanisms that it would be interesting to put in place to strengthen environmental accounting. Three major links, summarised in Figure 17. It details the relationships between the actual and prototypical accounts studied in this thesis.

The first would be to organise **conceptual exchanges** between the two levels. The communities that design these accounts need to start by talking to each other, which, as we have just seen, is almost never the case. This type of encounter is beginning to take place within the framework of the NCAVES project, the SEEA and the Natural Capital Coalition (IDEEA group, 2017). It will thus be possible to strengthen conceptual and semantic exchanges, to create a common language by aligning measurement principles and definitions.

The second link is the **exchange of data**. In economic accounting, this takes place mainly from the bottom up, as the construction of National accounts is based on the accounting documents of organisations. Throughout the world, it is indirect, through tax data or surveys. In France, the link is more advanced, since statisticians use accounting data directly. This enables them to provide the public sector with particularly accurate data on sectors of activity. As far as the environment is concerned, the links and exchanges have yet to be developed. The scarcity of data, which contrasts with the colossal needs for setting up a National accounting system for the environment similar to that used in the economic world, means that data sharing is a real challenge.

⁴⁴ It is possible that the authors have met.

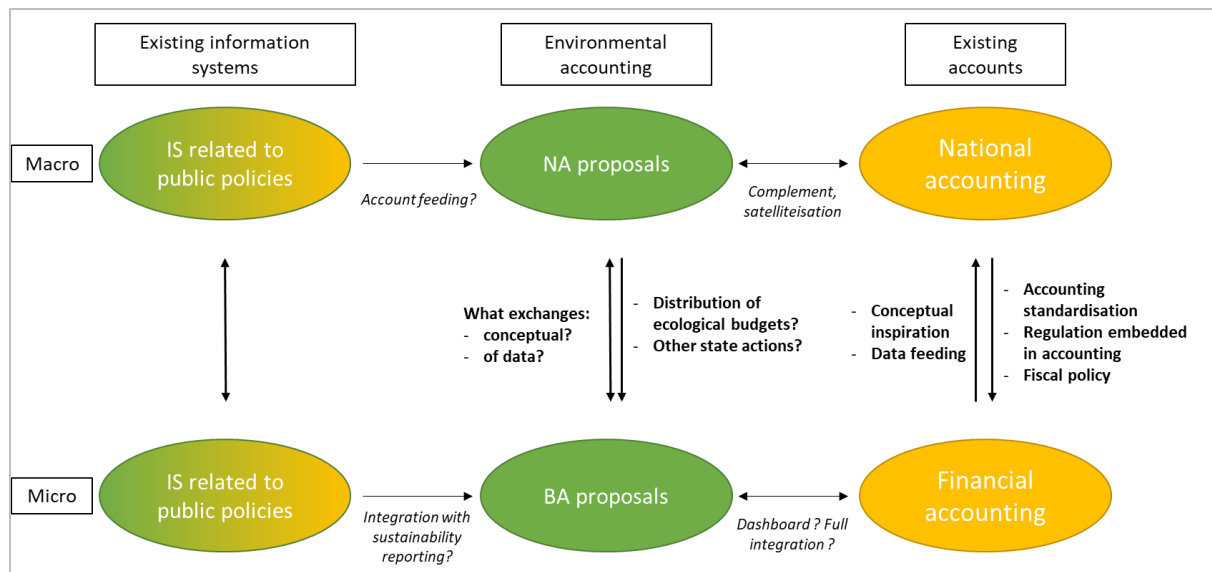


Figure 17 Articulation of subjects studied and key questions

Legend: the horizontal arrows represent the degrees of integration between information systems. The vertical arrows represent the relationships between micro and macro information systems. Green refers to proposed information systems; yellow to systems already in place.

The distribution of environmental data is very different from that of the economic world as it was when National accounting was introduced in the 1950s. Business accounting data was abundant at the time. This made it possible to create a national system based on company data. In the case of the environment, data is comparatively scarcer at these two levels. At this stage, the question of the distribution of data collection between the two levels is not closed. It is likely that two-way data exchange (micro data feedback and macro data provision) is the most realistic approach. Given the type of sustainability reporting that will be required from companies, it is possible that, roughly speaking, the following division of labour will emerge: General Government will be responsible for taking stock of the environment (stock), while companies will publish variations in its state (impacts, restoration actions).

Finally, a third link relates to **collective action**. In this case, the link is more top-down. Financial accounting provides a solid basis for a number of regulations and for reporting to the state. The depreciation mechanism is one such example (this accounting requirement ensures that money is set aside to preserve the capital contributed; and tacitly reinvested) (Richard, 2012b). Accounting is also an essential anchor for taxation.

Environmental policies could mobilise the framework of planetary limits to organise the sharing of ecological budgets down to the level of organisations (LCAbsolute, quoted by Wolff, 2017, p. 36) or to monitor the achievement of institutional targets (post-2020 framework, carbon neutrality, No net loss, good ecological status, etc.). *Science-Based Targets*, because they distribute environmental objectives from the (inter)national level down to companies, form a bridge between the national and organisational levels.

4.3. The three areas of research

This description of potential micro-macro links is naïve, utopian one might say, but it sets out the main areas of work to be explored. Based on these observations, a number of avenues are opened up for this thesis, particularly at the conceptual level, which is the first micro-macro link.

The three accounting approaches described above (SEEA, CARE and UEC) are important starting points for this thesis, but none of them satisfies all the conditions we seek. The current version of the SEEA offers some interesting biophysical accounts, although we will discuss some of the choices in Chapter 4. On the other hand, the reader may have sensed that the monetary accounts are designed from a weak sustainability perspective that is quite different from our position. We will demonstrate this in Chapter 3.

The key frameworks of the UECs are those we are looking for: a detailed biophysical system, the presence of monetary accounts enabling a strong sustainability approach (via the costs of achieving national environmental objectives and the recording of debts). Although this approach is anchored in National accounting with solid conceptual elements, it remains very general. Many points are left in the dark. In addition, it involves a great deal of modelling, which poses a problem for National accounting.

On the contrary, the CARE model is very detailed, thanks to the extensive programme of research and experimentation to which it has been subjected. Its theoretical foundation is solid, firstly in accounting and economics, and to a lesser extent in ecology (work is underway to strengthen the latter aspect, and this thesis hopes to make its contribution). Moreover, the proposed accounting structure is compatible with historical cost. On the other hand, it is a Business accounting model, which is not directly transposable to National accounting. As we shall see in Chapter 2, National accounting has in fact taken liberties with its predecessor.

Our conceptual work will therefore consist of 1) retaining most of the biophysical accounts of the ESEA and the founding principles of the UECs, while 2) translating the CARE model into National accounting. With regard to linking information (data) systems, we will mainly use the case studies on aquatic environments and terrestrial biodiversity to identify what is already accessible and can be linked. We will also have more general discussions on the question of how much modelling is acceptable for National accounting purposes. Finally, there will be discussions on the uses of and links between government action and business accounting.

Thus, to clarify the problematic of this thesis ("why and how to make links between national ecological debts and organisations?"), this chapter allows us to formulate three more specific questions, which will follow us particularly in the second half of the thesis:

- 1) What accounting policies should be used to manage environmental issues?**
- 2) What micro-macro links can we build on what already exists?**
- 3) What are the potential uses of the accounting systems we are proposing?**

This chapter has provided a framework for thinking about the third question. Before embarking on the design of new accounts, it is important to understand precisely the origins and nature of the micro-macro linkage that exists in economic accounting. This will provide clues as to the extent to which it should be reproduced. Moreover, monetary accounts, which are of particular interest to us, are the most controversial. Understanding these debates is an essential first step in building on past thinking and positioning our approach in this field of research.

Chapter 2 - The accounting basis of National accounting: history and articulation of concepts

1. Introduction to the chapter

National accounting (NA) is a representation of the economy that arose from the coming together of economics, accounting and statistics (Desrosières, 2010; Fourquet, 1980; Miller, 1986; Vanoli, 2002). In describing the disciplinary triangle that gave rise to national accounting, the authors dwell more or less on one pole or the other: Vanoli insists on the relative connection with economic theory, Desrosières provides many elements on the statistical nature of NA, while Miller and Fourquet spend more time describing the specificity of NA as a tool of government, management or power, as we saw in the previous chapter. Miller is the closest to business accounting, but he adopts the socio-political perspective of the accounting discipline much more than its technical dimension.

To propose an environmental extension of NA that respects the nature of this tool, we must therefore refer to these three disciplinary poles. Given our desire to link NA with Business accounting (BA), the accounting component of NA is a natural starting point for us. It is the subject of this chapter. However, it is difficult to find a description of the relationship between NA and BA that is suitable as a basis for an environmental extension of NA. To do so, we would have to be able to rely on a kind of accounting essence, a "fundamental substance" (Riahi-Belkaoui, 2012) around which more or less significant variations are organised over time, but which do not totally call this substance into question". (Rambaud, 2015, p. 52). Despite changes in international standards and practice, it remains relatively stable and timeless.

Unfortunately, national accountants do not seem to have considered the question in these terms. Of the authors cited above, only Vanoli devotes a discussion of several pages to the accounting anchoring of the NA. He dwells on various dimensions to which we shall return, but does not, it seems, describe such an essence. Elsewhere, there are discussions of attempts to make these levels coherent (Ruggles, 1996, cited by Vanoli, 2002) on the effects of reforms to the French chart of accounts on NA data sources data sources (Champsaur et al., 1998) relatively factual comparisons (Muller, 2019). Finally, other studies are strictly methodological and describe the transition from Plan comptable général (French GAAP) categories to NA categories categories (Hauseux, 2020; Magniez, 2009).⁴⁵ All these texts are very useful for understanding the historical paths of the accounting origins of the NA, for comparing its principles, or for seeing how BAs are used as a source of NA data. But they are not enough to identify the accounting essence we are looking for.

The closest thing to this is probably the body of technical texts drafted for the 1982 reform of the chart of accounts in France (Benedetti and Brunhes, 1971; Bouinot, 1971; Boutan, 1967; Boutan and Delsol, 1969) as well as much more theoretical texts (Arkhipoff, 1984). A final source, which needs to be exploited, is the texts of the founders of the French NA (Gruson, Vincent, etc.) who, unlike the Anglo-Saxons, sought to anchor the NA firmly in the BA.

On the other hand, we can usefully draw on the business accounting literature that details these theoretical aspects (Ijiri, 1982, 1975; Riahi-Belkaoui, 2012; Richard et al., 2018; Scott, 2012; Stolowy et al., 2010; Wolk et al., 2013). This is what Rambaud (2015, pp. 52-55) to put his environmental extension of historical cost accounting on a solid footing. To do this, he departs from accounting practice, which brings together the methods actually used to construct the accounts, with the necessary adjustments in relation to the charts of accounts. Although accounting standards are mandatory, they leave a certain amount of room for manoeuvre in practice. What's more, during

⁴⁵ These are used to inform the European institutions, which wish to take decisions based on the National accounting methods of the member countries, which are similar but not identical. The aim is also to align these methods as far as possible.

revision exercises, practice can be influenced by feedback from the field. Here, however, we need to go one step beyond standardisation and look at accounting models. These are influenced by economic conditions, political factors and accounting theory (Wolk et al., 2013). The latter comprises various branches, of which the most important for our purposes are:

- The theorisation of the company. The main ones are the entity theory and the owner theory.
- What has to do with valuation: conceptual theories of valuation, which need to be reconciled with historical financial accounting theories (Rambaud, 2015, p. 372; Richard, 2015). These theories are themselves based on a certain conception of capital (materialist, fundist, capital-money) and a Hicksian interpretation of income (Rambaud, 2015).

However, it is important to bear in mind that most of these theoretical elements were based on the company. If National accounting is to take a position on these elements, it is necessary to understand any translations that may have been made from the observation, no longer of a company, but of an economy. The two questions that this chapter seeks to answer are as follows:

- What is the accounting essence (as opposed to the statistical or economic essence) of National accounting?
- How has the essence of Business accounting been affected by its translation into National accounting?

The second is more particularly at the heart of the discussion. Compared with the previous chapter, it is no longer a question of seeking an accounting specificity in the uses of NA, but in its structure and the theoretical corpus that surrounds it. This chapter will thus serve as a basis for designing an environmental extension of NA that respects the "accounting constraint" that we introduced at the beginning of the first chapter. This will enable the translation of the CARE model into National accounting to be properly understood. The more practical question of metrology will also emerge, particularly in relation to the question of the sources used.

Figure 18 summarises the approach taken in this chapter. It shows the "ideal" approach and the steps actually taken. Given the sources available for this work, we began by studying the articulation and translation of the standardised business and NA frameworks. This is combined with an analysis of accounting practice.

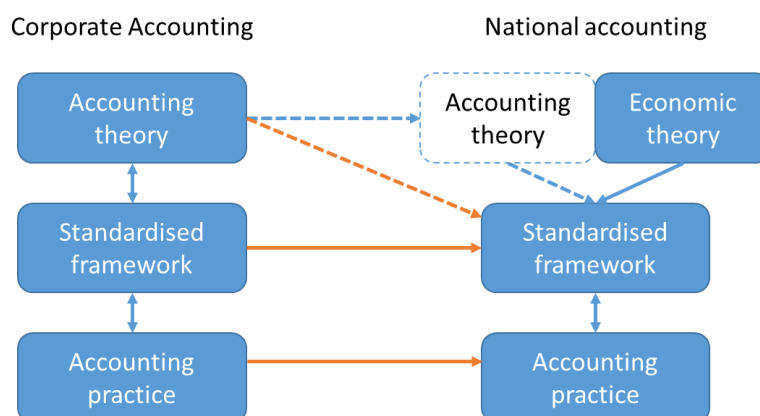


Figure 18 Simplified research approach (ideal and effective) followed in this chapter

Legend: adapted from (Wolk et al., 2013). The arrows correspond to a translation (which may be more or less faithful). The orange arrows are those we have actually studied. The blue arrows are other translations that we were unable to study. The NA accounting theory is dotted, as we were unable to identify it clearly.

We begin by presenting the complete Sequence of accounts as defined today. This section introduces the technical terms used in the rest of the chapter.

Then, to answer the research question, we will draw on three complementary approaches. They provide a starting point, but they are far from exhausting the subject or providing definitive answers to the two issues raised above.

The second part is a historical perspective. It will describe the gradual development of National accounting since the beginning of the last century. We will emphasise the disciplinary and theoretical origins, and the countries that have contributed most. We will see where the different elements of NA come from, in space and time, how they came together, how they were assembled, and why certain concepts were discarded. Naturally, this will shed light on the role of business accounting, as well as the mutual influences of business accountants and statisticians, particularly in accounting standardisation.

The third part looks at the current state of standardised frameworks. In particular, it compares the principles and definitions found in the 2008 System of national accounts (United Nations et al., 2011) and the French Plan comptable général (French GAAP) (Autorité des Normes Comptables, 2019). Business accounting theory will shed light on certain NA choices. Above all, it will provide an opportunity to open up new avenues of research or questioning. The aspects of particular interest to us are the major building blocks of NA: monetary valuation, liabilities, assets and the production account, which contains GDP.

Monetary valuation is absolutely central, since it is the method used to quantify accounting transactions. Competing approaches exist, and this is a particularly controversial subject in the environmental field (see next chapter). Secondly, we are naturally interested in the liability accounts, because this is the place where ecological liabilities are recorded. The CARE model creates new categories of natural assets that correspond to "uses of liabilities". We therefore need to study this concept in order to extend it to NA. In addition, "ecosystem assets" are a central concept in the SEEA. We will therefore eventually need to position our "natural assets" in relation to this approach. Finally, the CARE model separates preservation expenditure from other traditional costs. With regard to flow accounts, this is the most important question that the CARE model poses to national accountants. Indeed, this expenditure now appears in GDP. Can they be separated from it? If so, how? Answering these questions requires a detailed understanding of the production account.

Finally, the fourth part introduces methodological considerations relating to (national) accounting practice in France. We will present the sources used in NA. Finally, we describe the position of National accounting in relation to modelling, which is in tension with observation of the economy. All this will provide a fundamental understanding of the accounting nature of NA. In addition, since the environment is "outside the market", it requires a great deal of modelling, which may be a reason for rejecting certain approaches to environmental extensions. We therefore need to clarify what National accounting accepts as modelling, and why.

We will conclude with a discussion that draws together the lessons learned from these analyses and the contributions they make to this thesis.

2. Presentation of the Sequence of accounts

Let's start by describing the national accounts we are going to talk about. The Sequence of accounts (IOT) is one of the two National accounting tables. It tracks the various items of income creation and consumption (Table 6). The other table, known as the Input-Output table (IOT), or Leontief table, is not studied in this thesis because its structure is quite different from Business accounting. We will therefore confine ourselves to mentioning that it tracks product flows (goods or services). It therefore has a much more physical basis than the SOA, which is mainly concerned with monetary flows.

The SOA comprises flow accounts (current accounts and change in assets accounts) and stock accounts (assets accounts). Each account records a set of transactions (the rows) for the institutional sectors of the economy (the columns). The sectors are: Non-Financial Corporations (NFC), Financial Corporations (FC), General Government (GG), Households (HH), Non-profit institutions serving households (NPISH) and Rest of the World (ROW). The SOA is organised into two parts: resources, which include transactions that most often generate a positive inflow for the sector in question, and uses, which correspond to the consumption of resources.

Transactions are recorded in successive accounts. These accounts are linked to each other: the balance that enables us to balance one account (close it) is the resource of the next account. For example, the production account is closed by GDP, while the operating account opens with it. Each account provides an opportunity to add transactions that increase (resources) or decrease (uses) the entry balance.

We thus begin the production operations (imports and production itself as resources, exports and intermediate consumption as uses), which are balanced by the Value added, gross, also known as Gross domestic product. We have added the complete account as published by INSEE for illustrative purposes (Table 7). This first block describes the production process itself, which generates the income that will then circulate in the economy. This circulation is the subject of the rest of the IOT (Dufour, 2019, p. 110)..

Next come operating activities, i.e. compensation of employees, taxes and subsidies on products. All of these are counted as uses, according to the companies' point of view. The bottom line is Earnings before interest, taxes, depreciation, and amortisation.

The primary income distribution accounts bring together the operations of the previous account, but this time as resources for government and Households. Property income appears on both sides.

Table 6 Simplified Sequence of accounts

CURRENT ACCOUNTS													
Uses	NFC	FC	GG	HH	NPI	ROW	ROW	NPI	HH	GG	FC	NFC	Resources
Production													
Exports													Imports
Intermediate consumption													Output
VAG / GDP													
Generation of income													
Compensation of employ.													VAG / GDP
Taxes													
Subsidies													
Operating surplus													
Allocation of primary income													
													Compensation of employ.
													Taxes
													Subsidies
Property income													Operating surplus
Balance													Property income
Secondary distribution of income													
Taxes on income													Balance
Social contributions													Taxes on income
Social benefits													Social contributions
Disposable income													Social benefits
Use of income													
Final consumption expenditure													Disposable income
Savings													

STATEMENT OF CHANGES IN EQUITY													
Changes in assets	NFC	FC	GG	HH	NPI	ROW	ROW	NPI	HH	GG	FC	NFC	Changes in liabilities
Capital													
Gross capital formation													Savings
Consumption of fixed capital													
Net lending (+) or borrowing (-)													
Financial account													
Cash and deposits													Cash and deposits
Debt securities													Debt securities
Loans													Loans
Equity and investment fund shares													Equity and investment fund shares
Other changes in volume													
Non-financial assets													Financial liabilities
Financial assets													
Revaluation													
Non-financial assets													Financial liabilities
Financial assets													

ASSET ACCOUNTS													
Assets	NFC	FC	GG	HH	NPI	ROW	ROW	NPI	HH	GG	FC	NFC	Liabilities
Non-financial assets													
Produced													
Fixed assets													
Stocks													
Non-produced													
Natural resources													
Contracts, leases													
Financial assets													Financial liabilities
													Net worth
													Own funds (NW + shares)

The secondary distribution of income corresponds to the redistribution made by the General Government: income tax, contributions and social benefits. In resources or employment, depending on the sector.

The use of income account essentially brings together Households' final consumption expenditure and the remaining savings.

These savings are used to track changes in assets and liabilities over the course of the year. Liabilities are commitments (generally debts), while assets are, according to National accounting, stocks of value.

The change in assets accounts begin with the capital account. Savings correspond to a change in liabilities (it should be understood here that savings are a resource). It also includes capital transfers between sectors. Investments (gross fixed capital formation) appear on the side of (positive) changes in assets. Wear and tear, or the consumption of these assets, also appears on this side, but in negative: this is the Consumption of fixed capital. This account also includes changes in inventories and the acquisition less disposal of valuables. This account is closed by net lending (or borrowing).

From then on, the chain of accounts is broken. The financial account is relatively autonomous and records financial transactions: receipts and disbursements, acquisitions of financial assets and debts.

The other changes in volume account is used to record all changes in assets and liabilities that are not related to economic transactions (e.g. natural disasters).

Revaluations make it possible to take account of changes in relative prices (inflation, which may be linked to specific assets or affect the whole economy) and thus maintain consistency between the accounts for changes in assets and those for liabilities.

Finally, stock accounts bring together non-financial assets: they may be produced, such as housing, machinery, weapons systems, cultivated biological resources, stocks and valuables. Or they may not. This is the case with natural resources, which include cultivated and uncultivated land, mineral and energy reserves, and water resources. It also includes contracts, leases and licences, and goodwill.

Financial assets and liabilities, which are also included in assets and liabilities, are those mentioned above.

Table 7 Complete 2018 production account (source: INSEE)

Tableau Economique d'Ensemble : comptes courants de l'année 2018										En milliards d'Euros	
Total	Biens et Services	S2	S2	S15	S14	S13	S12	S11	S1	Ressources	
										Compte de prod. et compte ext. de biens et services	
737,4	737,4									P6	Exportations de biens et de services
755,6		755,6								P7	Importations de biens et de services
4 164,1				54,7	446,8	496,9	240,4	2 925,3	4 164,1	P1	Production
3 395,3				2,9	237,9	62,7	237,2	2 854,6	3 395,3	P11	Production marchande
298,1					209,0	15,2	3,2	70,7	298,1	P12	Production pour emploi final propre
470,7				51,7		419,0			470,7	P13	Production non marchande
2 073,2	2 073,2									P2	Consommation intermédiaire
262,2									262,2	D21N	Impôts moins subventions sur les produits

Tableau Economique d'Ensemble : comptes courants de l'année 2018										En milliards d'Euros	
	Emplois									S2	Total
Compte de prod. et compte ext. de biens et services											
P6	Exportations de biens et de services									737,4	737,4
P7	Importations de biens et de services										755,6
P1	Production										4 164,1
P11	Production marchande										3 395,3
P12	Production pour emploi final propre										298,1
P13	Production non marchande										470,7
P2	Consommation intermédiaire										2 073,2
D21N	Impôts moins subventions sur les produits										262,2
B1g/PIB	Valeur ajoutée brute/PIB										2 353,1
P51c	Consommation de capital fixe										429,2
B1n/PIN	Valeur ajoutée nette/PIN										1 923,9
B11	Solde ext. des échanges de biens et de services									18,2	18,2

3. Historical perspective: National accounting was freely inspired by Business accounting, then influenced by it

Let us open this chapter with a history of the NA which seeks to identify where and when the various elements of the current framework were brought together and aggregated in what would become the National accounting system. The various building blocks, in bold in the text, are quite numerous.

3.1. The founding developments, between Business accounting and nascent macroeconomics

After several centuries of statistical estimates of national income using very different and often experimental methods, the 1930s marked a real turning point which led to the creation of a system of accounts to represent the economy. Here we repeat the main elements described by Vanoli (2002, pp. 35-51) with a particular focus on those that were to form the basis of the structure of the Sequence of accounts.

The first aspect to highlight is the origin of the concept that has become central to all economic analysis, whether micro or macroeconomic: **value added**⁴⁶. According to Haller and Stolowy (1999) the theoretical roots of the concept can be traced back to around 1760, to the "theory of the economic circuit" that took shape in Quesnay's *Tableau Économique*. The concept was apparently formalised by the Englishman Young in 1770, although he also included the costs of repairing machinery. (Bos, 2017, citing Stone, 1997; Young, 1771). The short history of Value added from Haller and Stolowy (1999) then focuses on France and Germany, the countries where the concept was most widely used (especially in the former) and with little discontinuity. In Germany, we find in-depth reflections on Value added as early as 1916. But the most fertile period of reflection was the 30s and 40s (Haller and Stolowy, 1999)..

As far as economists are concerned, the Americans seem to be the first to think in terms of **accounting** (Vanoli, 2002; Vries et al., 1993, pp. 54-60). Irvin Fisher, in two publications from 1906 and 1928, had already mooted the idea of extending the accounting construct to the whole of society and, at least in principle, obtaining its capital and income by combining individual balance sheets and income accounts. In 1932, 1935 and 1937, Morris A. Copeland showed the advantages of using the double entry to estimate national income. Also in the United States, Robert F. Martin of the Commerce Department presented the idea of an economic accounting system. André Vincent, a member of the *Statistique Générale de la France*, worked on the idea of national accounting. He published these initial ideas in 1939. Two years later, Ed Van Cleeff published an estimate of national income in the form of National accounting in the Netherlands.

Outside a true accounting framework (absence of accounts, double-entry bookkeeping, individuals and transactions between them) and from a more theoretical perspective, a parallel current conceptualised the essential building blocks of what would become National accounting. Under the influence of Keynes and his seminal publication on macroeconomics, *The General Theory of Employment, Interest and Money* (1936), the work focused on **aggregates** rather than on the complexity and multiplicity of the operations that accounting records. With a much more synthetic aim, he then highlighted the series of fundamental equations that would focus interest on five variables⁴⁷:

⁴⁶ Strangely, Vanoli does not seem to mention its origin. According to the classic historiography of NA, he focuses on the notion of income (Vanoli, 2002).

⁴⁷ "Keynes's successor economists all saw the need to give quantitative form to the large economic masses whose importance Keynes had shown" (Claude Gruson quoted by Terray, 2003).

$$\text{Income} = \text{Production} = \text{Consumption} + \text{Investment}$$

$$\text{Savings} = \text{Income} - \text{Consumption} = \text{Investment}$$

This shows what the **three approaches to GDP** will be: income, production and consumption. Moreover, **savings** are highlighted, even though the concept does not exist in Business accounting. It is more a Households term, although it can be transposed elsewhere.

In 1941, at Keynes's suggestion, James Meade (1907-1995, Nobel Prize 1977) and Richard Stone (1913-1991, Nobel Prize 1984) published an estimate of English national income according to the three open perspectives. For each, a certain amount of detail is given, but no attempt is made to establish the links between the operations. The concept of **net output (later renamed Value added)** is already present. Another table in the appendix calculates the **capacity or need for financing**.

A second iteration of this work was published in 1945 by Stone. From an accounting point of view, the "Memorandum" could be described as loosely based on **cash accounting**, since it records only incoming and outgoing cash flows, but not all stocks and fixed assets, or debts. Stone describes a set of tables called **operating accounts** (which include purchases of raw materials in particular), **allocation accounts** (salaries), **capital accounts** (investment flows) and **reserve accounts** (with savings). The aggregates are classified according to the two columns of each table, revenues and payments. The double-entry method is used, since each transaction gives rise to an entry in two different accounts. For the first time, the four types of accounts are drawn up for different **sectors**: businesses, financial intermediaries, insurance and social security organisations, final consumers (including General Government) and the Rest of the World. The **quadruple entry** (double entry for both parties to the transaction) is partially respected. Accounting balances do not appear, but the tables are linked by "transfers" (sent or received) of the surpluses in each account.

This presentation had a major influence on the first standardised system published by the League of Nations (LoN) in 1947 (it was far ahead of its time). That said, the latter is slightly different from the "Memorandum", and struggles to strike a balance between a quest for synthesis (through aggregates) to make it easier to use, and the (accounting) rigour that is nonetheless necessary to convey the state of the economy⁴⁸. As a result, in Vanoli's opinion, "the account/aggregate duality is a hindrance. It will be a source of ambiguity" (Vanoli, 2002, p. 46). He adds that, in the LoN version:

"The move to the background of the basic accounting structure, the functional conception of the sectors⁴⁹ and the pre-eminence of the aggregates thus combined blur to the point of invisibility the idea of conceiving the construction of the nation's accounts as starting from elementary phenomena and resulting, at least in principle, from the aggregation of elementary economic accounts, actual or potential" (Vanoli, 2002, pp. 83-84).

This went on for more than 20 years, before the publication of the System of national accounts in 1968. It was not until the 1993 System of national accounts that national accountants completely got rid of this "thick representation" (Vanoli, 2002).

⁴⁸ The American *National Income and Product Accounts* (NIPA) face the same difficulty.

⁴⁹ In the Anglo-Saxon conception, sectors are not defined as sets of legal units keeping individual accounts, but by considerations of their economic nature and role.

3.2. The French synthesis adopts a rigorous accounting approach

After briefly following the international momentum until 1949, particularly in connection with the Marshall Plan, France took a completely different direction in 1950 and embarked on the development of what was to become the **Sequence of accounts** (Vanoli, 2002, pp. 69-106). This work, which was independent of the international community, was to make a major contribution, stemming from a sharp criticism of the League of Nations system. It should be noted that in 1952, the United Kingdom adopted a presentation similar to that constructed by the French, a single table cross-referencing sectors and accounts, before abandoning it in 1956. But it never achieved the accounting rigour sought in France (Vanoli, 2002, p. 75). Aukrust (1949) proposed a similar representation, but without considering its construction on the basis of the aggregation of elementary agent operations.

After the seminal work of André Vincent, the main international advances spread during the 1940s via François Perroux (1903-1987; behind the creation of the Institut de Sciences Économiques Appliquées), who also conducted in-depth conceptual research on National accounting. At the same time, the Service des Études Économiques et Financières (SEEF; part of the French Treasury) developed its own System of national accounts to feed into the indicative planning work of the Commissariat général au Plan and the economic budgets. This direct application of economic statistics within an interventionist framework is a key element in understanding a large number of design choices (Desrosières, 2008a, 2008b; Fourquet, 1980; Miller, 1986; Vanoli, 2002).

The head of the SEEF, André Gruson, published a book (1949) and then a memorandum (1950) that were to have a profound effect on French NA. *The outline of a general theory of economic equilibrium. Réflexions sur la théorie générale de Lord Keynes (Reflections on the General Theory of Lord Keynes)* was the first result of his familiarisation with the nascent field of macroeconomics. Despite what the title suggests, Keynes is an influence to be kept in perspective. For Gruson, the aim was not to apologise for what Keynes had said, but to support his own reflections. The latter, partly inspired by the pre-war German model (where dirigisme based on military industry helped the country to emerge from a deep economic crisis), drew inspiration from Keynes to develop as rigorously as possible a doctrine of state intervention with a degree of dirigisme in a liberal economy (Terray, 2003).

The note he wrote the following year included a **representation of the economic cycle** that attempted to trace, if not exhaustively, at least a **very large number of economic operations**. The result was 88 equations, which was a very large number for the time, but the development of mathematical machines by physicists led Gruson to believe that this complexity would be manageable in the near future. Looking back Vanoli (2002, pp. 71-72) notes that the level of detail is more important than the overall vision: "although their aggregates are rigorously defined and calculated, they are not the main objective of the accounting system, which is not subordinate to them. [France] is therefore not part of the historical tradition which, over the previous two decades, saw the emergence of the accounting approach mainly as a means of providing a better basis for determining the aggregates [...] and enriching them".

Why such detail, when the Anglo-Saxons were content at the time with a much more aggregated view? Gruson replies that:

"It was an idea that stemmed from the fact that the accounts of the basic players could be grasped through taxation, and in order to explain changes in global magnitudes and global phenomena as a whole, we have to try to link global phenomena to the microeconomic phenomena of which they are made up. In this respect, there is a great deal of controversy among economists, who take the famous '*no-bridge*' approach: there is no bridge between the

behaviour of the individual actor and overall behaviour. However, if you want to explain things, to make them intelligible, you have to build that bridge, more or less skilfully, but you have to build it, and that's what I insisted on from the start". (Claude Gruson, quoted by Terray, 2003).

His department then published a memorandum, commonly referred to as the "Principles". (Fourquet, 1980; Vanoli, 2002) which served as the basis for the economic table. Vanoli (2002, p. 87) explains that the **elementary transactions of business accounting are aggregated** into classes of transactions with the same economic significance: transactions in goods and services, exchanges in kind, sales of second-hand goods, stock movements, transfers and financial transactions. Agents each have three accounts:

- An operating account showing purchases and sales. It begins with **net production** (future value added), which is not detailed, and ends with **gross operating income**. This is the first time that such a balance has appeared.
- An appropriation account, understood in a very broad sense, since it includes salaries, loans, etc. The account ends with the "financing of equipment and inventories".
- A **capital account** balanced by gross **investment** (which is equal to the previous balance).

The structure of Keynes's equations, which set out the key elements to be measured, is also apparent. These are the subject of explicit accounts or balances so that they can be monitored and the relationships between them identified. The coherent sequence of accounts is also more elegant and integrated than that of Stone. Finally, the level of detail provided is much greater. This is linked to the idea that:

"the integrated accounting representation was conceived as being able to be applied in principle both at the level of a national economy as a whole and at that of each of the institutional microeconomic units (economic agents, one might say, "in full operation") that make it up" (Vanoli, 2019a, p. 31)..

The table then has a square shape, with debits in the columns and credits in the rows. If the concepts of credit and debit are used here, a business accountant would certainly find their use awkward. They were replaced in 1959 by resources and uses (Vanoli, 2002).

The real development of French National accounting (CNF) then began and lasted until 1962. After that, France was involved in standardising the European Economic Community's accounting system.

In 1954, the first **table of financial transactions** (TOF; still separate from the rest of the accounts) was published, showing resources and uses. The flows passing through the Treasury were represented in great detail, in connection with the economic budgets. This table does not yet show changes in assets and liabilities - the form adopted from 1960 onwards - in order to be consistent with the resources and uses of the other sectors. In particular, this meant that borrowings were recorded as resources and repayments as uses, whereas both transactions would later appear under changes in liabilities.

It should be noted that this construction of the financial account as a "change in assets" is completely out of step with company accounts, which do not explicitly take account of financial flows in the profit and loss account (which only shows stocks at the end of the period). National accounting, in regular discussion with the Treasury, needed to represent the economy's financial accounts in great detail in order to manage the many complex financial mechanisms used to steer the economy.

The following year, the *Tableau Économique d'Ensemble*, whose name is a reference to Quesnay's *Tableau Économique*, was introduced. This time, the **rectangular presentation** was used (with sectors in columns and transactions grouped in accounts in rows). As in an income statement, resources are

on the right and uses on the left. The three accounts open and close with a balance: the operating account begins with gross domestic production as a resource and closes, on the assets side, with gross operating profit; the latter opens the appropriation account as a resource, which closes with savings; the capital account opens with savings and closes with net lending or borrowing.

Although the capital account includes Gross fixed capital formation - investment - (as well as changes in inventories), the opposite flows, i.e. depreciation, do not appear at all in the table. Nor does the company's "accounting result" appear, because the viewpoint of the manager and owner of the company is not that of the State, which has a more neutral view of Households. What matters to it is its own role in redistribution⁵⁰.

The **quadruple part** is respected and tracked in "screen accounts", separate tables to preserve the elegant synthesis of the SOA.

The SOA then underwent only minor adjustments, before being taken international. The harmonisation of statistics in the young European Economic Community brought the French back onto the international stage. In 1964, Vanoli prepared "Proposals for a Community framework for National accounting", in which he took up the spirit of the French approach. In the face of difficult discussions (Germany considered the IOT to be a planning approach, which was frowned upon at the time⁵¹), Stone's intervention was decisive: at the end of 1964, he proposed to the UN a "System of national accounts" extremely similar to the French National accounting system. Certain countries wanted the European framework to be in line with that of the UN, and this was what enabled it to be accepted. (Vanoli, 2002, pp. 122-124). That said, the "account sequence" was not really aligned with the French SOA until 1993.

3.3. The influence of National accounting principles on charts of accounts

The introduction of Generally agreed accounting principles (GAAPs), which impose a codification of company accounts (definition and arrangement of accounts, regularity of inventories, accounting period, etc.), is essentially favoured by macro-actors, the State or employers, wishing to intervene in the economy, through more or less flexible planning, centralised or not, or to create statistical information systems (Richard et al., 2018, pp. 186-189). The United States, Great Britain, Australia and Canada, which are more liberal, do not impose any (there are no rules governing the chart of accounts, but there are guidelines on evaluation and the presentation of summary documents). On the contrary, in 2013, countries such as France, Spain, Russia, China and Vietnam have a GAAP. Germany is a special case: it was the (isolated) driving force behind the creation of National accounting before the war (Desrosières, 2008b; Richard et al., 2018). However, it abandoned the idea of a GAAP and allowed employers to propose two versions, which coexist and are widely used today.

Depending on the type of intervention in the economy, these countries have chosen to generalise the use of monistic and dualist accounting systems (Richard et al., 2018, pp. 186-189). Dualist accounting systems involve a separation between general accounting, which is public and based on intermittent inventories, and cost accounting, which is secret, unregulated and based on continuous inventories.

⁵⁰ This aspect was taken a step further with the publication of allocation accounts by socio-professional category. This work, which Vanoli describes as a 'curiosity' (p.104), was continued until the mid-1980s, sometimes with difficulties (biased responses from Households on income), and then resumed after 2000.

⁵¹ Nazi Germany created a major system of authoritarian economic planning. In reaction, after the war, any idea of planning was discredited, although mechanisms for guiding the economy were retained (Desrosières, 2008b, p. 145).

General and cost accounting lead to the same result, but the reading of the operating cycle is "blurred" in the former by the intermittent inventory of stocks and by the classification of expenses by nature⁵² and not by function⁵³. This system is used in continental Europe, but especially in France and its sphere of influence. It is tending to disappear in favour of the monistic system (Richard et al., 2018, p. 117)..

Thus, monistic plans were created by governments or employers wishing to have strong control over production, or at least to be able to compare them (Russia, China, Vietnam, Germany). Dualist plans, on the other hand, were created by governments wishing to have more flexible control over the markets, while at the same time following macroeconomic variables (as in the case of France and its former colonies, Belgium, Spain and Germany). Countries that do not impose a chart of accounts often see the more or less spontaneous development of monistic accounting, a single system that is more in tune with the way companies operate. Slight harmonisation is encouraged by the publication of "rules for the valuation and presentation of accounts using a conceptual framework". (Richard, 1999)..

Governments are not the only ones to draw up rules for publishing accounts. In this case, we are not talking about a real chart of accounts, but about standards or norms. International Financial Reporting Standards (IFRS), for example, were developed by a private body with a clear financial focus. Their purpose is to promote the production of information to help listed companies make investment decisions. In addition to producing autonomous standards, this standard-setting body influences existing Generally agreed accounting principles (Colasse and Standish, 1998; Richard et al., 2018)..

Following this general perspective, let's return to France (for a comparative chronology of the NA and the reforms to the French Plan Comptable Général (French GAAP), see the Appendix C). Before the advent of National accounting, there were two stages in accounting standardisation (Colasse and Standish, 1998).

The first was Colbert's *Ordonnance* of 1673, which "required merchants, traders and bankers to keep certain accounting records and, in the case of merchants and traders, the important additional requirement that their account books be registered with a civil authority" (ib.). This was not intended to help taxation, which was not based on business profits, but to promote "social cohesion" (ib.), in the same way as the written French language.

The second stage, in 1942, was the drafting by the Vichy government of an accounting plan that was not fully applied (Colasse and Standish, 1998). The codification and publication of accounts were intended to enable prices to be monitored and controlled, while at the same time providing a detailed picture of business performance. This link with national statistics, as well as price controls on certain markets and administrative structures, were retained after the war to form the basis of National accounting and the Generally agreed accounting principles (Fourquet, 1980; Miller, 1986).

The period 1946-1975 saw the birth of the French Plan Comptable Général (PCG), which was deeply influenced by the State's interventionist approach. Quite naturally, its governance reflected this orientation (cf. Figure 19 The governance of the PCG between 1946 and 1958 was very similar, albeit simplified and with a less important role for employers). It should be noted that the link between the PCG and taxation was established by decree in 1965.

⁵² Consumption of materials, services, labour (wages and salaries) and equipment.

⁵³ This classification, also known as by destination, includes the following classes: sales production costs, commercial costs, administrative costs, financial costs, etc., which better reflect the way the business operates.

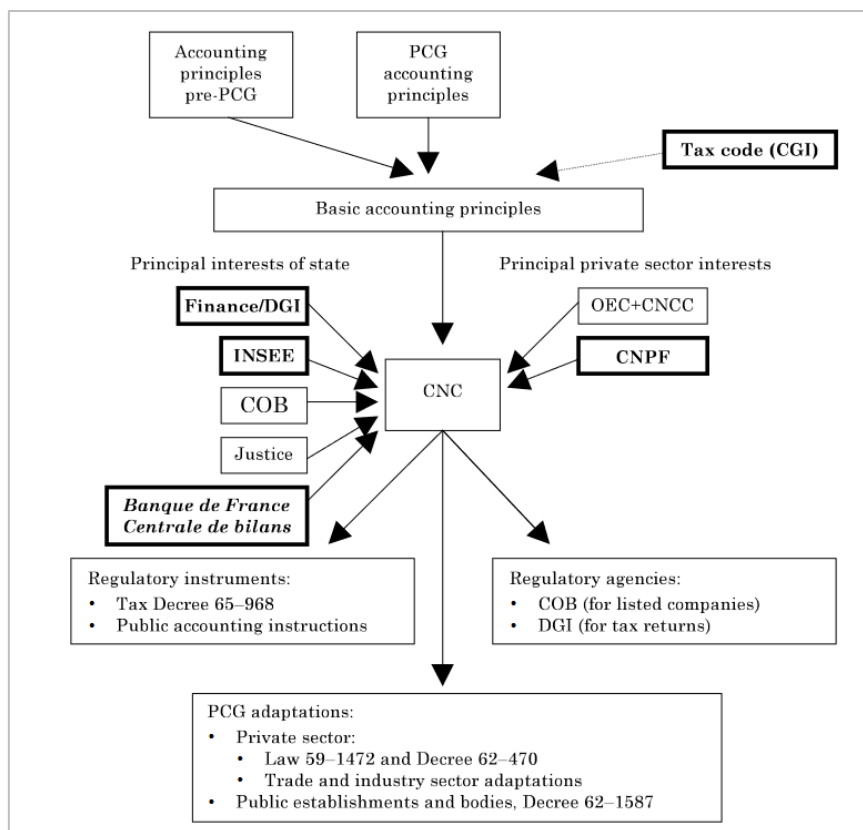


Figure 19 French accounting standardisation process (1958-1975) (source: Colasse and Standish, 1998)

Legend: PCG: Plan Comptable Général (French GAAP); DGI: Direction Générale des Impôts; COB: Commission des Opérations en Bourse; CNC: Conseil National de la Comptabilité; CGI: Code Général des Impôts; OEC: Ordre des Experts-Comptables; CNCC: Compagnie Nationale des Commissaires aux Comptes; CNPF: Conseil National du Patronat Français. In bold: the most influential bodies.

Although begun in the 1947 and 1957 PCGs, Richard et al (2018, p. 190) point out that it was paradoxically at the end of the golden age of National accounting that the PCG truly confirmed its macroeconomic orientation (Richard, 1999). Colasse and Standish (1998) give two reasons for this: the delay in aligning public accounting with National accounting and the shortage of resources in terms of accounting training, which was inherited from the war and is still prevalent.

It was the reform launched in 1971 and culminating in the 1982 PCG that definitively validated the **recording of expenses by nature** in order to facilitate the calculation of Value added (VAT) and Earnings before interest, taxes, depreciation, and amortisation (EBITDA). The definition of products also becomes **overall production** (including that which is stocked or fixed asset) (Richard et al., 2018, p. 330). This period was rich in conceptual exchanges and comparisons between BA and NA, particularly between statisticians (for example: Benedetti and Brunhes, 1971; Bouinot, 1971; Boutan, 1967; Boutan and Delsol, 1969). However, a balance is maintained between the demands of statisticians, which are quite numerous (see Benedetti and Brunhes, 1971) and the needs of companies (Vanoli, 2002, p. 248). As a result, cost accounting was not standardised and disappeared from the PCGs quite early on under the influence of companies, which were unhappy about the growing interference of the State in their business. (Richard, 1999).

It was national accountants who introduced the concepts of VAT and EBITDA into financial analysis (Benedetti and Brunhes, 1971; Colasse and Standish, 1998) which at the time had "only a rather vague meaning for many industrialists" (Benedetti and Brunhes, 1971). Financial analysis was still in its

infancy: the Société Française des Analystes Financiers was founded in 1956, and developed a field which had grown in the United States at the end of the nineteenth century^e, focusing essentially on the study of solvency and profitability ratios (Horrigan, 1968). In this analysis, VAT gained in popularity in the 1970s, including abroad (Burchell et al., 1985; McLeay, 1983) to the point where it rapidly became indispensable, even if controversy initially arose (Goetzke, 1979; Rutherford, 1977). Boutan and Delsol (1969) confirm the novelty of this trend:

"It is not surprising, therefore, that some of the concepts [defined by the French National accounting system] are beginning to spread. For example, committees and articles devoted to value added are springing up everywhere.

In reality, although the French NA brought these concepts to light by giving them an 'official' definition, calculating them and using them extensively in economic policy, particularly in the context of planning, the concept already existed. As we have seen, Keynes, although he called it something different, was already referring to it, certainly on the basis of the work of Quesnay and the Germans of the 30s and 40s (Haller and Stolowy, 1999). But the standardisation of this concept and its regular use have greatly contributed to its establishment in people's minds. By taking shape in the practices of quantification, publication and decision-making, this was the decisive moment for GDP to become pre-eminent in public policy. The determination to make it grow, which is still present today, is first and foremost the mark of a generation that wanted to rebuild the country in a productive and modernising spirit.

At the time, VAT was all the more readily adopted because it met a demand from the private sector: "companies want to place their prospects within a general framework" and in particular to have a sectoral vision (Boutan and Delsol, 1969).

From the 1980s until the early 2000s, French accounting standard-setting essentially followed the same principles as in the previous two decades. However, the opening up of standard-setting bodies to the influence of IFRS, both more directly (through their consultative presence in France) and indirectly (through the transposition of European standards for consolidated group accounts), has introduced financial or at least more liberal conceptions. Another player that has grown in importance is the French judiciary, as a result of the "increased regulatory specification of accounting standards (Colasse and Standish, 1998).

4. Conceptual comparison of Business accounting and National accounting

The previous section highlighted the various origins of National accounting (NA). It is now time to look in more detail at the translations made by national accountants in order to grasp the BA.

This section describes the accounting structure of economic NA in order to identify the contributions and translations of business accounting, not in its slow historical development, but in its construction as it is today. Although the two types of accounting, Business accounting and National accounting, are based on a set of common principles, there are also differences at all levels of conception (theoretical principles, scope of the constituent blocks, definition of accounts, method of monetary valuation). We will therefore seek to understand precisely what these differences are and why they exist⁵⁴.

4.1. General principles

To begin this analysis, it is necessary to compare the principles of NA and BA. A number of points of convergence and divergence in the concepts used are worth highlighting.

National accounting and business accounting **record a set of events concerning an entity** (national economy; person or company) with assets and liabilities. They use a chart of accounts to represent the internal interrelationships of the unit concerned, as well as its relationships with other entities (Rest of the World in NA; buyers, creditors and lenders in ES).

Both share a number of concepts and are based on similar theoretical underpinnings: theory of value (or standard capital theory), notions of employment, resources, assets and liabilities, but also more precise concepts such as Intermediate consumption, remuneration, credits, etc. There is a shared vocabulary, but the definitions do not always coincide, and vice versa. National accounting, for example, gives priority to economic theories over accounting concepts if the two do not coincide (United Nations et al., 2011, para. 1.64). This enables it to achieve its objectives of macroeconomic analysis and public decision-making more accurately. In this way, production, consumption and capital formation move away from the concept of the firm. This is also why the BA does not use historical cost, but exchange value, which is "the best practical approximation to opportunity cost accounting [...] as defined by economic theory" (United Nations et al., 2011, para. 1.65) (see below). Other differences appear for the valuation of inventories and Consumption of fixed capital (to be distinguished from BA depreciation) (United Nations et al., 2011, para. 1.67).

"The idea of drawing an analogy with double-entry bookkeeping appeared at the beginning of the 20th^e century and was developed in the 1930s". (Vanoli, 2002). The NA accounting **data structure** was then established, using a set of accounts in which values are entered using the double-entry (or quadruple-entry) method, and which are linked together in a coherent manner.

This is reflected first and foremost in the structuring of **accounts**. One notable difference in the use of accounts is that they are used to record and centralise BA transactions, whereas the NA only uses the second function of centralisation (Bouinot, 1971).

⁵⁴ This section is essentially based on three types of text: historical articles written in France at the time of the reform of the Plan comptable général des entreprises (French GAAP) which culminated in 1982, the accounting standards themselves (NA and BA) and a manual detailing INSEE's methods of "transition to the accounts".

Secondly, there is a **coherent chain of** accounts based on intermediate balances. Broadly speaking, we can say that in NA, as in BA, there is a logical link between the profit and loss accounts, which are flow accounts, and the balance sheet, which covers stocks. The link between the two is made by the change in assets and liabilities accounts, which are annual flows. These change in net worth accounts are similar to the cash flow statement that business accountants can set up (Benedetti and Brunhes, 2004). (Benedetti and Brunhes, 1971). The sequence and breakdown of the accounts are described in more detail in the following sections.

Finally, in both cases, **double-entry** recording allows the information entered to be checked. Transactions involving an agent or an institutional sector are all recorded by crediting and debiting one or more accounts. However, because there are several institutional sectors in NA, transactions corresponding to exchanges or transfers (monetary or otherwise) between agents are recorded for both. Four accounts are therefore credited or debited, which makes it possible to speak of a quadruple part. In this way, the lines are balanced. More often than not, the employment of one agent is the resource of another (United Nations et al., 2011, para. 1.63). On this subject, there are two interesting quotes:

"Broadly speaking, two main axiomatic approaches can be considered, those of the flows (bifluxes) involved in the so-called Anglo-Saxon systems and those of the summation of the elementary accounts of the economic units making up the nation (the "French" point of view, at least from 1955 onwards [...], if not from 1945 onwards, but with an "Anglo-Saxon" parenthesis from 1950 to 1955). This can be summed up as follows: is national accounting an accounting of flows (from biflux: quadruple-entry accounting) or an accounting of accounting systems?

"In conclusion, national accounting is only accounting indirectly: it is more or less implicitly assumed that the properties of the double entry are preserved in the additive aggregation of elementary accounts, which is therefore only true to a first approximation. In other words, the accounting paradigm is first and foremost a matter of theoretical interpretation, at the level of the atoms of National accounting, so to speak. We can therefore only agree with Archambault when she writes: "National accounting presents statistical information within an accounting framework, but it is not, strictly speaking, accounting" [3], p. 23." (Arkhipoff, 1984)

For practical reasons in particular, the NA cannot **seek the exhaustiveness** characteristic of the BA. The NA accounts are compiled using methods and information from very different sources (surveys, accounts, modelling). This information is collected by statisticians and then assembled by National accounting officers, who sometimes have to fill in the gaps by making trade-offs that are more or less explicit, well-founded and constant over time. Examples of this are the territorial and CAF/FAB corrections⁵⁵ and the adjustment accounts. In the final analysis, the NA is seen as "the presentation of information from a wide variety of sources within a balanced accounting framework". (Piriou et al., 2019).

The precautionary principle (Richard et al., 2018, pp. 65-68) is relatively complex and can be understood in different ways. At first glance, it can be said to apply to NA and BA in both cases, but

⁵⁵ Exports from France are always valued at FOB (free on board), which includes transport costs to the French border, but not beyond. Imports are valued at CIF (Freight Insurance Cost), if they include transport costs to the French border, or FOB otherwise. CIF imports must therefore be corrected to make them comparable with exports, but only global correction factors are available.

with a different gradation. In BA, we find the realisation principle, which stipulates, in its translation by the Plan comptable général (French GAAP) that "only profits realised at the end of a financial year may be entered in the annual accounts" (Art. 313-2 of the French Commercial Code, in Richard et al., 2018, p. 67). In NA, this is explained by the time of recording, which is done on an accruals basis. With regard to dividends (one of the elements at the centre of attention when talking about the principle of prudence, along with investments), the 2008 SNA states that "it is difficult to allocate dividends unequivocally to a specific period: they should therefore be recorded at the time when the corresponding shareholding begins to be quoted 'ex-dividend'" (United Nations et al., 2011, para. 3.171). At least in France and Germany, the BA uses an additional principle, the "imparity" principle, which involves counting potential losses but not potential gains. In particular, it influences the choice of whether to capitalise or expense certain investment expenses. From this point of view, the BA is more cautious than the NA, whose concept of investment (Gross fixed capital formation) is very broad. At the other end of the spectrum, IFRS are the least conservative standards in existence. Following failed attempts to remove the principle altogether, IFRS have retained only a light and fuzzy version of the prudence principle (Richard et al., 2018, pp. 65-68).

4.2. Monetary valuation method

Valuation methods differ between NA and BA. We will therefore present them in turn, stopping briefly at the transition between the two.

4.2.1. Business accounting

In BA, there are three valuation methods⁵⁶.

The first is **historical cost** (Richard et al., 2018, p. 217) According to this method, assets are valued *at full cost* (acquisition cost, production cost or exchange cost). The completeness of costs means that they must incorporate non-values in the static accounting sense, such as registration fees, expenses, etc., and they must include interest on loans, "wasted" costs, a share of overheads, etc. At *the stocktaking stage*, assets intended for use (fixed assets, stocks of raw materials) are valued at their entry cost at constant price⁵⁷, less depreciation. Assets sold and intended for sale (inventoried products) are valued at their market price. The same principle applies to liabilities. The value of other assets (fixed assets) does not change, which means that the result is not influenced by market fluctuations.

This approach to valuation is characteristic of dynamic accounting, and is that of the French Plan Comptable Général (French GAAP). It favours entrepreneurs and, to a certain extent, the owners of the company.

The second valuation method is the **market price** (Richard et al., 2018, p. 200 and following) This method uses the price observed on active markets. For a long time, this method was used to value the balance sheet as a whole in the context of so-called static accounting, which excluded many investments and costs from the balance sheet, which were recorded as expenses. Under this system, incoming assets are valued at acquisition cost, excluding expenses, which are impossible to resell.

⁵⁶ We refer to Richard et al (2018, p. 271) to understand the valuation of the resale value of a business, a method of valuing the business as a whole, and not the assets taken one by one with a view to liquidation.

⁵⁷ In other words, inflation is taken into account. The reason why the SNA 2008 (para. 1.66) says that inflation is not taken into account in the BA is that, in practice, assets are rarely revalued, even though this is provided for in the chart of accounts.

Goods produced by the company are valued at market price. In the inventory, goods that cannot be sold on a market have a zero value, while other goods are marked to market with a capital gain or loss. On the liabilities side, internal debts (provisions) have no value.

At the time, the aim was to liquidate the company in order to protect creditors. This method is now only used for assets held for sale (production). This method is mainly recommended by the IASB, which issues IFRS standards.

The third method is **present value** (Richard et al., 2018, p. 235). The value of assets is given by the discounted sum of future cash flows generated by the use of the asset. This involves estimating the net present value of the business and then allocating this value to the assets (which poses significant theoretical problems). The IASB proposes to use these valuations for non-marketed assets (Richard et al., 2018, p. 210). This method favours shareholders, who are in a financial analysis perspective.

It should be noted that the differences are not due to whether or not inflation is taken into account. All accounting systems can do this without changing their nature. The differences to be borne in mind here are as follows:

- Historical cost is based on a **realisation** principle: only figures observed at the time of the events are recorded.
- The market price is based on an **observation** principle: assets and finished products, even if not sold, are estimated at current market value.
- The present value is not realised or observed, but **calculated**.

Once this description of the framework in force has been made, we can move on to a more stable accounting essence, on which these methods would be firmly based. In this chapter, we will only mention the existence of a close link between the monetary valuation methods mentioned and such a theoretical corpus which crosses certain conceptions of the company, profit and capital (which is in any case something to be preserved, as demonstrated by Rambaud (2015)). The main approaches and corresponding visions are summarised in Table 8 taken from Rambaud (2015, p. 386).

These concepts have a number of characteristics that interest us: they favour the information needs of certain players, who in turn support them. Moreover, implementing them in real accounting models has effects on an economy's path towards sustainability or non-sustainability from an economic and environmental point of view. In particular, environmental extensions based on one or other of these conceptions can lead to the continued degradation of environments, or to their preservation (Rambaud and Feger, 2019). Fully mobilising these theories allows this to be formally demonstrated.

4.2.2. Questions relating to the micro-macro transition

The transition to National accounting requires us to question the validity of these principles of monetary valuation and the corresponding theories.

Are the theories of income and capital adopted as they stand, or do they need to be translated? If so, how?

Do we retain the entity theory or the owner theory? Here, the two poles of the NA, accountants and economists, may clash: accounting practice mostly retains the entity theory, while neoclassical economics retains elements of the owner theory. Should the two theories be articulated?

If we consider that these theories are primarily applicable at the individual level, these questions seem unavoidable when moving on to National accounting. This is particularly true if we consider NA as flow accounting. It is probably less so if we consider it as an accounting of individual accounts (Arkhipoff, 1984). Depending on the reductionist perspective adopted in NA, the second case probably makes it possible to retain the theoretical elements that prevail at the micro level. On the other hand, a National accounting of flows can be more easily abstracted from the micro level, because the individual accounts are seen only as a source of data.

These questions merit further investigation beyond the scope of this thesis, but we feel it is important to mention them. As a first approach, the elements linked to the company level can be used as a grid to analyse what is said about monetary valuation in NA.

Table 8 Summary of the Hicksian capital maintenance accounting model (source: Rambaud, 2015, p. 386)

Type of "capital" (Capital Ontology)	Capitalist Capital (Capital)		capital-money
	Fundist approach	Materialist approach	
Balance sheet equation	Owner theory		Entity theory
Relationship between firm and capital holder	The Enterprise is an Object for the Capital Owner		The firm is fully dissociated from the holder of the money-capital: the profit made is that of the firm
Substance of capital	Capital is dependent on the activity of the Company Assets are Objects of Capital		Capital is an entity independent of the enterprise's activity
Capital at the firm level	Net asset accounts (concept linked to a debit)		Capital account (concept linked to a credit)
Relationship btw assets and capital	Assets: shares of total capital support		Assets: shares in the use of capital money
Valuation	Via assets Present value	Via assets Market value	Monetary own value
Elements specifically related to the Hicksian capital maintenance model			
"Location" of capital maintenance	Subject shareholder/owner's accounts		Company's accounts
Capital maintenance operation	Reinvestments (preferably in funds)	Reinvestments (preferably in terms of inventories)	Setting aside certain sums of money
Capital profit (resulting from an intrinsic change in capital)	Changes in dividends and expected interest rates of the fund capital (+ changes in the general price level) + Change in Fund Capital "volume"	Specific price changes and external wear and tear on stock capital items (+ changes in the general price level) + Variation in the "volume" of Material Capital	Change in the general price level + Variation in "volume" of money capital
Relationship of this model to existing financial accounting	Actuarial accounting IASB trend	Entry Value Accounting Pre-Classical Accounting	Static accounting (if holding period = accounting period) Dynamic accounting (if holding period ≠ accounting period ≠ operating period + Allocation of expenses and income to the financial year + Principle of continuity) Indexed accounting (if dynamic accounting assumption + taking into account the variation of the general price level)

4.2.3. National accounting

Here, it is important to bear in mind the distinction between the valuation of income and other flows, and that of inventories (assets and liabilities). The point of divergence with business accounting relates solely to inventories, since BA and NA flows are valued at current prices.

The 2008 SNA states that goods and services are valued at market price. It specifies that:

"The SNA does not attempt to determine the utility of the flows and stocks that fall within its scope. Rather, it measures in monetary terms the current exchange values of accounting records, that is, the values at which goods and services, labour or assets are or could be exchanged for cash." (United Nations et al., 2011, pp. 50-52).

The mention of utility is there to remind economists of the real purpose of the NA: to observe transactions. It therefore keeps its distance from economic theory.

If no market exists, estimates can be made using various methods: similar or fictitious markets, valuation at production cost, with depreciation (for assets) or without (for products), and as a last resort by Net Present Value (NPV). In any case, this price must be distinguished from concepts such as world price, quotation, fair price or current price, which are estimates of categories of trade that are assumed to be identical. At first glance, therefore, we find the same three main valuation methods used in business.

With regard to the choice of valuation at market price, three types of justification are mixed together: theoretical arguments from economists, historical inertia, and the needs of the analysis. Vanoli points out that while the use of NPV is more in line with the theoretical definition of the value of an asset, paradoxically it is recommended as a last resort because of the imprecision and uncertainty it generates in practice (Vanoli, 2002, p. 407)⁵⁸. The concept of production costs is widely used to value the output of General Government. Hicks justifies this by interpreting these costs "as significant from the point of view of social choices and aggregable to market values" (Vanoli, 2002, p. 324). These costs thus reflect a collective willingness to pay. In contrast, François Perroux placed great emphasis on "the inconstitubility in principle, from the point of view of the theory of value, between measurement by market prices and measurement by adding up costs". (Vanoli, 2002, p. 71)..

Vanoli also explains that this method of monetary valuation was adopted from the very beginnings of National accounting and that historical cost was rejected from the outset (Vanoli, 2010). Initially, this was linked to the focus of National accounting on flow values (production, income, etc.), estimated by market values. The late adoption of this framework by asset accounts meant that this valuation method had to be retained for stocks, for practical reasons of consistency between stock and flow accounts (NPV, 2022; Vanoli, 2002). We find this argument difficult to understand: companies' income statements are also valued at market value, while part of the balance sheet is valued at historical cost, and this is not a problem.

Elsewhere, Vanoli justifies this choice by the impossibility of aggregating values from different periods, due to inflation. From the point of view of economic analysis, this would make no sense (Vanoli, 2002,

⁵⁸ The SNA and Vanoli are a good match:

"In theory, the value of a fixed asset is the present value of the sequence of gross operating results, net of tax, expected from its use and any anticipated residual value". (Vanoli, 2002, p. 409)

" 3.38. Since assets constitute a reserve of future benefits, all assets can be represented by a monetary value. This value represents the market's view of the total benefits embodied in the asset." (United Nations et al., 2011)

p. 442) especially when it comes to studying long periods when inflation may have been significant. This argument is valid, but it focuses on a very specific aspect: the monetary valuation method itself. One source of confusion arises from the common name for this method and the corresponding theoretical accounting model. Thus, Vanoli's argument does not allow for a wholesale rejection of the theoretical historical cost model, which includes other elements (a conception of capital, income, a particular accounting structure, etc.).

In fact, National accounting does not seem to have gone as far in analysing accounting theory as the authors working at company level (Ijiri, 1975; Rambaud, 2015; Riahi-Belkaoui, 2012; Richard, 2015; Scott, 2012; Stollowy et al., 2010; Wolk et al., 2013). In particular, they continue to be based on a capitalist, fundist or materialist vision, depending on the time and the person, and it seems that they are unable to decide between the two approaches (Vanoli, 2002, pp. 444-446). The vision of capital as money, the basis of historical cost accounting, is not understood. Its specificity and its profound *raison d'être* in Business accounting are not really perceived (Richard, 2015). Moreover, this has led to "problems of interpretation" of Hicks' income by National accounting and certain economists (Vanoli, 2002, pp. 458-463). Mobilising the frameworks described above (Rambaud, 2015) might help to clarify the issue.

There is some confusion about the term cost between business accounting and NA. A historical debate in NA concerns valuation at "factor cost" or "market price". (Vanoli, 2002, pp. 324-328). It was restricted to the valuation of production, and did not concern the value of assets in the balance sheet. Basically, this discussion was not at all about the design of a static or dynamic accounting system, at market price or historical cost. The question was whether or not to include taxes and subsidies on products. In the 1993 SNA, several choices were made. In the input-output tables, prices must be meaningful to economic agents and be available in usable databases (Piriou et al., 2019, p. 33). Some common corrections are therefore made. A distinction is made between uses and resources. Production (resource) is valued at the **basic price**, i.e. the price received by the producer on sale, adjusted for taxes and subsidies on products. This is the producer's actual revenue per unit produced. Taxes include VAT, which is paid to the State, and certain subsidies exist to support incomes (agriculture) or lower selling prices (SNCF, etc.)⁵⁹. On the uses side, the significant price is the **acquisition price**, the price paid by the purchaser. This is the sum of the base price plus transport margins, commercial margins and product taxes (the only VAT counted here is deductible VAT). This is commonly referred to as the "market price". In the Sequence of accounts, this market price is used exclusively to value production.

Finally, from a practical point of view, we can see that the differences in valuation methods mean that there is no insurmountable obstacle to making the transition from business accounting to NA. A certain amount of effort is required to adjust business accounting values. This is particularly the case between historical cost and cost base, where the differences are as follows: a revaluation of fixed assets at the current market price; an adjustment to income taxes.

⁵⁹ Imports are subject to additional special treatment, known as CIF (Cost Insurance Freight) adjustment, because insurance and transport costs from the country of origin are not always included in the purchase price.

On the other hand, from a theoretical point of view, a number of points remain to be clarified in order to decide whether the logic of the historical cost accounting model can be transferred to the NA. At this stage, we will assume that this is possible, based on the principles of the CARE model.

4.3. Between flows and stocks, the search for an accounting result

In this section, we look at the main components of accounting: how flows and stocks are designed and how they are linked by balances. With regard to these balances, in particular, we will ask what accounting results are highlighted.

The breakdown of the BA and NA accounts follows a similar logic, i.e. the search for a result for the period which is a flow: savings for NA, net profit for BA. Figure 20 shows that there are differences in the definition of this result and in the division of the blocks (Bouinot, 1971).

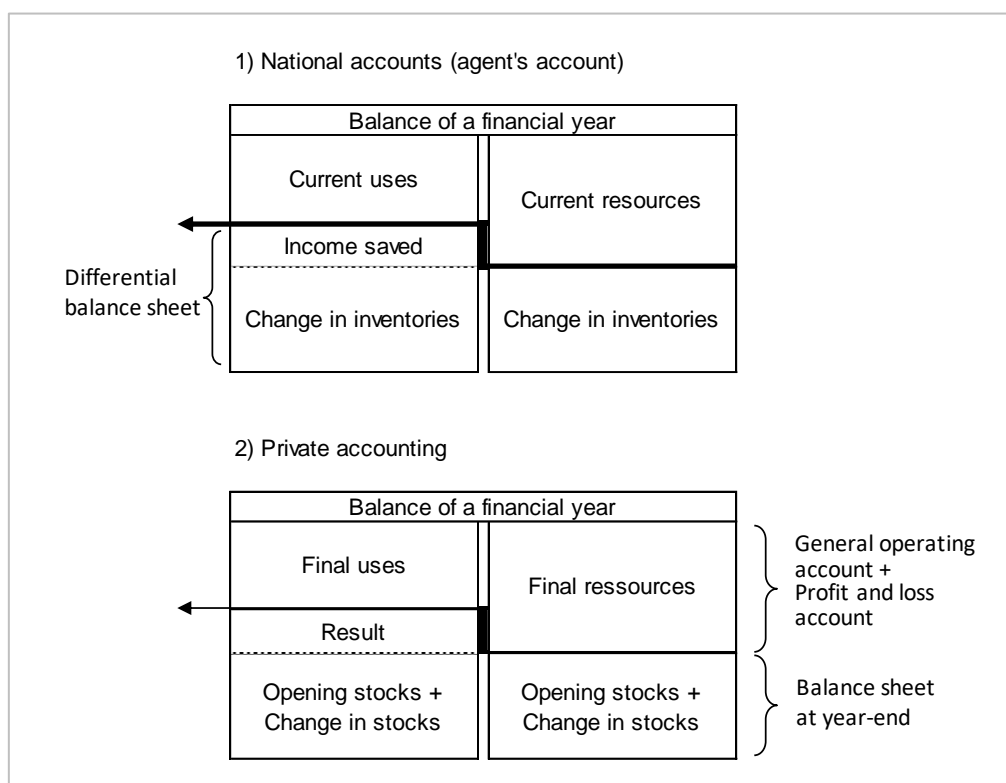


Figure 20 Breakdown of the balance of resources and uses using accounting techniques (source: Bouinot, 1971)

National accounting works on the basis of current resources and uses, which implies a particular division between income and capital (or assets). Thus: "current resources and uses are those that present a certain regularity over time and a close link with production activity conceived as an intentional and predictable source of income" (Bouinot, 1971). A requirement for equality between national incomes and products leads to the exclusion of "non-produced results" when calculating savings. In particular: depreciation allowances (and write-backs), provisions, exceptional profits and losses and profits and losses on previous financial years. Consumption of fixed capital is therefore included in the change in net worth account.

The company distinguishes between recording definitive uses and resources and those that are pending at the end of the period. The definitive aspects are recorded in the income statement, in the form of income and expenses, while the pending aspects await settlement in the balance sheet (assets

are pending expenses, liabilities are forward repayment commitments). The profit or loss for the year, as its name suggests, summarises past transactions. In this way, the income statement reflects the independence between financial years, while the balance sheet provides the link between them.

Another difference means that the parallel between net savings (NA) and profit for the financial year (BA) is not exact: savings are calculated after redistributions and income tax, whereas profit for the financial year is calculated before these operations (accounting net profit is closer, except that dividends are not yet paid and the valuation methods are different). In addition, changes in assets and liabilities include revaluation and adjustment accounts, whereas in BA, adjustments do not exist and revaluations are not the subject of specific accounts⁶⁰.

4.4.Cash flow statements: an almost exact parallel up to EBITDA, then divergences

A number of studies have bridged the gap between Business accounting (BA) and National accounting (NA) and offer a number of particularly interesting points of analysis (Benedetti and Brunhes, 1971; Braibant, n.d.; Muller, 2019). This section takes up some of these elements and supplements them with more recent sources:

- Hauseux (2020), Magniez (2009) and Malherbe (n.d.) describe the conceptual divergences between BA and NA. Here we take up those identified as major by Hauseux (2020, p. 215)⁶¹.
- Financial analysis courses (Rambaud, 2019; Richard et al., 2018) for the modern description of companies' intermediate management balances (IMB).

⁶⁰ Accounting systems that take account of revaluations due to inflation do exist, but they are neither in common use nor the subject of accounting standards in France.

⁶¹ In the production approach: "FISIM, transformation into basic prices, removal of lands, R&D into GFCF, financial leases [3.4.3], transformation of change in inventories into basic prices, net non-life insurance premium, UCITS (see 3.3.2.3 Conceptual adjustments)".

In the income approach: "compensation of employees, taxes on production and imports, subsidies, gross operating surplus and mixed income" (p.215).

It also states that: "By the business general plan of accounts (PCG), the balance between the closing balance sheet and the opening balance sheet is equal to change in inventories (with a business definition): $\Delta_{\text{business balance sheet}} = \text{business change in inventories}$. In National accounts, it is not equal to changes in inventories (or transactions): $\Delta_{\text{NA balance sheet}} = \text{NA changes in inventories} + \text{other changes in volume} + \text{holding gains and losses}$ " (Hauseux, 2020, p. 306). A summary figure is given in Appendix E.

<u>IMB logic</u>	<u>IMB</u>	<u>NA accounts</u>
	<i>Sale of goods</i>	NA
	+ Production sold of goods	Market production
	+ Production sold of services	Market production
<i>Company activity</i>	= <i>Turnover</i>	NA
	- <i>Purchase of goods</i>	NA
-	- <i>Change in stocks of goods (IS-FS)</i>	NA
-	= <i>Trade margin</i>	Market production
-	+ Capitalized production	Output for own final use
-	+ Stocked output (FS-IS)	Market production
<i>Consumption for the year from third parties</i>	- Purchase of raw materials	Intermediate consumption
	- Change in raw materials inventory	Intermediate consumption
	- Other purchases and external charges	Intermediate consumption (part goes into GFCF, property income or interest)
Creation of corporate value	= Value Added	Value added
-	+ Operating subsidy (74)	Grant
-	- Taxes (63)	Taxes on production
-	- Personnel costs (64)	Compensation of employees (including 69)
Industrial and commercial performance	= Earnings before interest, taxes, depreciation, and amortization (EBITDA)	Operating surplus (in French, same wording as BA)
-	- Depreciation, amortisation and operating provisions	Similar to CFC; Provisions excluded; Depreciation in other volume changes
-	+ Reversals of depreciation, amortisation and operating provisions	
-	+ Other operating income	Market production (75 except 755)
-	- Other operating expenses	Intermediate consumption (65 except 655)
Result	= Operating result	NA
<i>Financial result</i>	+ Financial income	Mostly property income (D4). Also appears in the P of financial services
	- Financial expenses	Mostly property income (D4). Also appears in the P of financial services
Pre-tax results from normal operations	= Earnings before tax (EBT)	
-	- Employee participation (69)	in employee remuneration
-		Primary income balance
-	- Income tax (IS)	Current income tax (D5)
-	+ Extraordinary income	Transfers (D75, D62 and D9)
-	- Exceptional expenses	
-	= <i>Extraordinary result</i>	
End result	= Net accounting result	Savings
	+ <i>Depreciation and amortization</i>	<i>Resembles the CFC (which is actually recalculated)</i>
-	+ <i>Allocation to provisions</i>	NA
-	- <i>Reversals of provisions and depreciation</i>	NA
Amount of money generated by the company	= Self-financing capacity (SFC) or Cash flow (CF)	Different definition
-	- Dividends to be paid N+1	in Distributed income of companies (D42)
-	= Self-financing	NA

Table 9 summarises the comparison of BA and NA accounts. It shows the NA accounts and balances side by side with the intermediate management balances of modern financial analysis. This shows the identical, similar and divergent elements. This comparison only concerns flows. We note that up to EBITDA, the structure of the accounts is very similar and the restatements are secondary. After this balance, the logic changes more dramatically and the NA accounts and the BA intermediate management balances diverge significantly. There are also more restatements to make the transition to the accounts. This divergence occurs at the time of income distribution. We interpret this as the shift from a business logic, where production and exploitation are central, to a Households logic, which

prioritises the distribution and use of income. The perspective of the business manager is replaced by that of the citizen, even if, of course, all the institutional sectors are represented right up to the end of the sequence.

The logic changes again when we move on to the capital account (change in wealth). This time, it is the economist's point of view that prevails: investment flows - and disinvestment - as the engine of growth are highlighted.

<u>IMB logic</u>	<u>IMB</u>	<u>NA accounts</u>
	<i>Sale of goods</i>	NA
	+ Production sold of goods	Market production
	+ Production sold of services	Market production
<u>Company activity</u>	= <i>Turnover</i>	NA
	- <i>Purchase of goods</i>	NA
-	- <i>Change in stocks of goods (IS-FS)</i>	NA
-	= <i>Trade margin</i>	Market production
-	+ Capitalized production	Output for own final use
-	+ Stocked output (FS-IS)	Market production
<i>Consumption for the year from third parties</i>	- Purchase of raw materials	Intermediate consumption
	- Change in raw materials inventory	Intermediate consumption
	- Other purchases and external charges	Intermediate consumption (part goes into GFCF, property income or interest)
<u>Creation of corporate value</u>	= Value Added	Value added
-	+ Operating subsidy (74)	Grant
-	- Taxes (63)	Taxes on production
-	- Personnel costs (64)	Compensation of employees (including 69)
<u>Industrial and commercial performance</u>	= Earnings before interest, taxes, depreciation, and amortization (EBITDA)	Operating surplus (in French, same wording as BA)
-	- Depreciation, amortisation and operating provisions	Similar to CFC; Provisions excluded; Depreciation in other volume changes
-	+ Reversals of depreciation, amortisation and operating provisions	
-	+ Other operating income	Market production (75 except 755)
-	- Other operating expenses	Intermediate consumption (65 except 655)
<u>Result</u>	= Operating result	NA
<i>Financial result</i>	+ Financial income	Mostly property income (D4). Also appears in the P of financial services
	- Financial expenses	Mostly property income (D4). Also appears in the P of financial services
<u>Pre-tax results from normal operations</u>	= Earnings before tax (EBT)	
-	- Employee participation (69)	in employee remuneration
-		Primary income balance
-	- Income tax (IS)	Current income tax (D5)
-	+ Extraordinary income	Transfers (D75, D62 and D9)
-	- Exceptional expenses	
-	= <i>Extraordinary result</i>	
<u>End result</u>	= Net accounting result	Savings
	+ <i>Depreciation and amortization</i>	<i>Resembles the CFC (which is actually recalculated)</i>
-	+ <i>Allocation to provisions</i>	NA
-	- <i>Reversals of provisions and depreciation</i>	NA
<u>Amount of money generated by the company</u>	= Self-financing capacity (SFC) or Cash flow (CF)	Different definition
-	- Dividends to be paid N+1	in Distributed income of companies (D42)
-	= Self-financing	NA

Table 9 Comparison of intermediate management balances (IMB) and NA balances (source: author)

Legend: in blue, the accounts and balance corresponding to a company's commercial activity (where applicable); in green, the parallels are exact or almost exact; in orange, there are significant differences that do not call the parallel into question; in red, the parallel is tenuous. The figures correspond to the accounts in the Generally agreed accounting principles (French GAAP); the codes comprising a letter and figures are accounts in the sequence of national accounts.

Having briefly introduced this table, we will now describe in more detail the micro-macro transition for these accounts. The reader can refer to

IMB logic	IMB	NA accounts
	<i>Sale of goods</i>	NA
	+ Production sold of goods	Market production
	+ Production sold of services	Market production
<i>Company activity</i>	= Turnover	NA
	- Purchase of goods	NA
-	- Change in stocks of goods (IS-FS)	NA
-	= Trade margin	Market production
-	+ Capitalized production	Output for own final use
-	+ Stocked output (FS-IS)	Market production
	- Purchase of raw materials	Intermediate consumption
Consumption for the year from third parties	- Change in raw materials inventory	Intermediate consumption
	- Other purchases and external charges	Intermediate consumption (part goes into GFCF, property income or interest)
Creation of corporate value	= Value Added	Value added
-	+ Operating subsidy (74)	Grant
-	- Taxes (63)	Taxes on production
-	- Personnel costs (64)	Compensation of employees (including 69)
Industrial and commercial performance	= Earnings before interest, taxes, depreciation, and amortization (EBITDA)	Operating surplus (in French, same wording as BA)
-	- Depreciation, amortisation and operating provisions	Similar to CFC; Provisions excluded; Depreciation in other volume changes
-	+ Reversals of depreciation, amortisation and operating provisions	
-	+ Other operating income	Market production (75 except 755)
-	- Other operating expenses	Intermediate consumption (65 except 655)
Result	= Operating result	NA
Financial result	+ Financial income	Mostly property income (D4). Also appears in the P of financial services
	- Financial expenses	Mostly property income (D4). Also appears in the P of financial services
Pre-tax results from normal operations	= Earnings before tax (EBT)	
-	- Employee participation (69)	in employee remuneration
-		Primary income balance
-	- Income tax (IS)	Current income tax (D5)
-	+ Extraordinary income	Transfers (D75, D62 and D9)
-	- Exceptional expenses	
-	=Extraordinary result	
End result	= Net accounting result	Savings
	+ Depreciation and amortization	Resembles the CFC (which is actually recalculated)
-	+ Allocation to provisions	NA
-	- Reversals of provisions and depreciation	NA
Amount of money generated by the company	= Self-financing capacity (SFC) or Cash flow (CF)	Different definition
-	- Dividends to be paid N+1	in Distributed income of companies (D42)
-	= Self-financing	NA

Table 9 to understand the comparisons made in the rest of this section.

4.4.1. Production, a common concept

The concepts of production are very similar. It is possible to draw up a table showing the transition between the two types of accounting (Figure 21). A company's sales margin is used to calculate its output. This is then summed with the production of goods and services (sold or stored) to obtain market output. Thus, the concept of turnover does not exist in NA.

The main difference⁶² is not strictly speaking a correction of the BA, but rather an extension of the scope of production in National accounting. It is linked to the introduction of Households, which requires the calculation of the own-account dwelling rental service.

La production en donnée d'entreprise		
Production marchande (P11)		
Intitulés	Variables ESANE	Comptes PCG
+ ventes de marchandises	+ R401	707, 7097
- achats de marchandises	- R210	607, 6097
+ variations de stocks de marchandises	- R211	6037
= marge commerciale		
production vendue de biens	+ R402	701 à 703, 7091 à 7093
production vendue de services	+ R403	704 à 708 sauf 707, 7094 à 7098 sauf 7097
production stockée	+ R311	713
autres produits d'exploitation *	+ R315	75 ** sauf 755

* Cette ligne de la déclaration fiscale incluait auparavant le compte 73 « produits nets partiels à long terme » : cette disposition comptable a été supprimée (règlement CRC n° 99-08 du 24 novembre 1999) mais le phénomène qu'elle traduisait existe toujours. Il est aujourd'hui géré selon le système de « comptabilisation à l'avancement ».

** La définition et l'usage de ce compte en comptabilité d'entreprise avaient été inspirés par d'anciens concepts de comptabilité nationale selon lesquels certaines recettes relevaient de répartition de revenus et non de productions (guide Lefebvre 2008 « la notion de "production" de la comptabilité nationale a été retenue »).

Les concepts de comptabilité nationale ont évolué, de sorte que la majeure partie des sommes enregistrées en compte 75 sont aujourd'hui considérées comme des productions, soit principalement :

- **compte 751 : redevances** pour concessions, brevets, licences (la plupart des revenus d'actifs incorporels entrent dans le champ de la production, même lorsqu'il s'agit d'actifs « non produits », voir aussi ;
- **compte 752 : revenus des immeubles**

Production pour emploi final propre (P12)		
Intitulé	Variables ESANE	Comptes PCG
Production immobilisée	+ R312	72

Figure 21 PCG-ESANE transition table for production (source: Braibant, n.d.)

4.4.2. Intermediate consumption and production costs: minor differences

The concept of Intermediate consumption (IC) is a creation of the NA, which brings together a certain number of charges included in the calculation of Value added. In NA, IC is "the value of goods and services consumed as inputs to a production process, excluding fixed assets whose consumption is

⁶² The more marginal corrections are as follows: correction for deliveries between establishments of the same company, correction for own-account production of R&D software, correction for the sale of land by property developers, correction for property transfer costs, etc. (Malherbe, n.d.). (Malherbe, n.d.).

recorded as Consumption of fixed capital." (United Nations et al., 2011, para. 6.213). The BA sometimes refers to them as consumption for the financial year from third parties (Rambaud, 2019). Expenditure included in the calculation of VAT for NA and BA is very similar in scope (Figure 22).

Les consommations intermédiaires en donnée d'entreprise		
Intitulés	Variables ESANE	Comptes PCG
Achats de matières premières et autres approvisionnements	+ R212	601, 602, 6091, 6092
Variations de stocks mat prem	- R213	603 sauf 6037
Autres achats et charges externes	+ R214	604 à 606, 6094 à 6096, 61, 62
Autres charges d'exploitation	+ R222	65 sauf 655
Solde des opérations en commun *		
(quotes-parts de bénéfices transférés et pertes supportées)	+ R202	655
moins pertes transférées et bénéfices attribués)	- R302	755

* Ce solde apparaît lorsque plusieurs entreprises organisent une opération de production en commun : une entreprise assure la gérance de l'ensemble et enregistre toutes les opérations comptables, soit directement dans ses comptes, soit dans une comptabilité séparée. A la fin de l'exercice, l'entreprise gérante calcule le résultat de l'opération et le ventile entre les différentes entreprises participantes. C'est la quote-part lui revenant que l'entreprise enregistre dans les opérations en commun. En somme des entreprises participantes ce solde doit être nul, il doit donc être pratiquement nul au niveau macroéconomique. Il a été décidé en base 2005 de poursuivre le traitement des bases 95 et 2000, c'est-à-dire d'inclure cette variable dans le calcul de l'opération P2 Consommation intermédiaire.

Figure 22 PCG-ESANE transition table for Intermediate consumption (source: Braibant, n.d.)

There are, however, some secondary differences. These do not call into question the interpretation of the concept of Value added. Rather than introducing a profound divergence between operating expenses and ICs, the corrections made by the NA are intended to be more consistent with what is a factor of production and what is not.

The first difference is in the treatment of **financial intermediation services**: interest rates on bank loans are restated to extract the commissions that are part of the intermediation service (and that the financial company charges to its operating costs) and what is part of the cost of capital itself. Similarly, only the part of **insurance premiums** that corresponds to the service for the customer is included in Intermediate consumption (note: this does not include life insurance). Net premiums and premium supplements, which make up the remainder of insurance premiums, are recorded elsewhere. In the same vein, income from undertakings for collective investment in transferable securities (and therefore Intermediate consumption by the units that pay them) is treated in the same way.

In BA, all **rents** are recorded on a legal basis. Thus, rents on buildings and land are expenses for those who pay them. In NA, some rents are recorded in the "property income" account (in employment for those who pay them). This is the case for rents on land and concessions for access to subsoil resources. (Hauseux, 2020, p. 77).

Another difference concerns **R&D expenditure**: since the ESA 2010, most of this expenditure gives rise to the creation of an asset and is therefore recorded as gross fixed capital formation (whereas previously it was all intermediate consumption). (Hauseux, 2020, p. 77). In the PCG, there is an

exception for companies to record certain applied research expenditure in the same way as NA. In practice, however, this exception is not used for tax reasons (Richard et al., 2018, p. 539).

Leasing, which is recorded as an expense in BA in the same way as other lease payments, is restated in NA, in line with the prevailing concept of economic ownership. The NA considers that ownership (economic) is transferred to the lessee (legal), which results in Gross fixed capital formation. The lender (legal) sees the non-financial asset transformed into a receivable. The amount of the (legal) rent is considered to be the repayment of a loan. (Hauseux, 2020, p. 100).

4.4.3. Common interpretation of value added

To be perfectly rigorous, we cannot say that the VAT of the NA corresponds to the sum of the VAT of the BAs because of the corrections mentioned for Intermediate consumption on the one hand, and the extension of production because of the introduction of Households on the other. However, their logic is exactly the same.

In BA, a company's Value added measures the value it creates over the course of a financial year. It depends solely on its own production choices (Rambaud, 2019).

With regard to its interpretation and use at both levels, statisticians such as Benedetti and Brunhes (1971) explain that while "the head of a company can generally be satisfied with his turnover to judge the progress of his firm", Value added "represents a far superior indicator". "It provides a much more reliable measure of the size of a company (or group) and the development of its business" (ib.). It thus represents its contribution to the creation of value in its own sector of activity and in the national economy. From another perspective, once the role of the state via its taxes and subsidies has been removed, VAT "represents the contribution of labour and capital to the production process." (United Nations et al., 2011, para. 6.71).

4.4.4. Subsidies and operating taxes: a direct parallel

Taxes on production are directly aligned between the BA and the NA (cf. Figure 23 and Hauseux, 2020; Magniez, 2009).

Les impôts en donnée d'entreprise		
Intitulés	Variables ESANE	Comptes PCG
Impôts et taxes	+ R215	63
dont (détails)		
taxe professionnelle *	R702	63511
taxe intérieure sur les produits pétroliers (TIPP)	R494	
* En 2010 la taxe professionnelle est supprimée, remplacée par la CET (contribution économique territoriale, décomposée en CFE (cotisation foncière des entreprises, assise sur la valeur de l'immobilier) et CVAE (cotisation sur la valeur ajoutée des entreprises, assise sur la valeur ajoutée fiscale)).		
Les subventions en donnée d'entreprise		
Intitulés	Variables ESANE	Comptes PCG
Subventions	+ R313	74

Figure 23 Transition table for taxes and subsidies on production (source: Braibant, n.d.)

4.4.5. Staff costs: slightly different coverage

It should be noted that personnel costs are similar, but that the NA uses a broader definition: they include employee profit-sharing (BA account 691).

Les salaires en donnée d'entreprise		
Intitulés	Variables ESANE	Comptes PCG
D111		
Salaires bruts	+ R216	641, 644, 648
Participation des salariés aux résultats	+ R205	691
Salaires personnels de l'exploitant	- F101	644
D121		
Charges sociales	+ R217	645, 646, 647
Cotisations personnelles de l'exploitant	- R502	646

Figure 24 Wage transition table (source: Braibant, n.d.)

Social security contributions are also included here, as they are in BA (cf. Figure 24 and Hauseux, 2020; Magniez, 2009).

4.4.6. Common interpretation of Earnings before interest, taxes, depreciation, and amortisation

Earnings before interest, taxes, depreciation and amortisation measures the industrial and commercial performance, or structural profit, of a company's operations. It includes the compensation of employees, as well as subsidies and taxes on production. EBITDA is not dependent on investment and financing policy, unlike the following balances (Rambaud, 2019, p. 58). Unlike the NA, social contributions are subtracted now to calculate EBITDA, which is quite a significant difference.

In NA, **EBITDA** is the balance of the operating account, which describes the distribution of value added to labour (compensation of employees), to General Government (taxes on production and imports; subsidies) and to capital (EBITDA itself). In other words, it "is a measure of the surplus generated by production processes before the explicit or implicit amounts corresponding to interest charges, rents and other property income payable are deducted" (United Nations et al., 2011, p. 7.12). Further on, we find the same interpretation as in the BA: "Operating surplus or mixed income does not depend on whether the land is owned or not or, more generally, on how the assets are financed" (United Nations et al., 2011, para. 7.13).

4.4.7. Discrepancies over the recognition of wear and tear on assets

From this point onwards, the rationales of the national accounts and the intermediate management balances begin to diverge seriously. Only a tenuous thread allows us to draw a parallel between the two types of accounting.

Boutan and Delsol (1969) In their preparatory work for the reform of the chart of accounts, Boutan and Delsol envisaged a net operating result common to both NA and BA. This was to be calculated by deducting from the previous balance (EBITDA), "economic" depreciation (including "conventional interest", industrial depreciation, which is itself linked to "wear and tear, ageing and obsolescence", but not to tax considerations) and a revaluation of inventories. In their view, calculating depreciation was difficult, but could still be a separate entry in this account. The rest of history decided otherwise: the large amount of modelling that was finally necessary for the macroeconomic calculation of

"depreciation" excluded it from this place and removed the net operating result from the sequence of national accounts.

On the other hand, on the company side, the logic has been retained in its entirety: **operating profit** (REx) is another operating profit, in the same way as EBITDA. It is calculated by deducting depreciation, amortisation, impairment and operating provisions, and adding back depreciation, amortisation and impairment. This balance is therefore very closely linked to the company's investment choices in its production base, its core business. It remains independent of the financing policy. In the analysis, it is important to understand the difference between EBITDA and REx, because some investment efforts are justified without jeopardising the company's future performance. (Rambaud, 2019, p. 59).

In NA, provisions are nowhere to be found. BA depreciation allowances are not used by statisticians to calculate its macroeconomic equivalent, the Consumption of fixed capital (CFC). This is calculated by statistical methods that use other concepts, closer to economic analysis. In addition, this aggregate appears several times in the current accounts, to calculate net balances. However, it is actually recorded in the capital account, which is itself part of the changes in assets and liabilities accounts. Impairments, for their part, also appear in changes in assets, in the "Revaluation" account if the changes in value are linked to price changes, or in the "Other changes in volume" account otherwise.

4.4.8. Distribution of primary income vs. analysis of financing policy

From this point on, it should be noted that an important conceptual leap takes place: whereas the previous accounts and balances can be broken down by branch of activity (which groups together segments of companies producing the same good or service), the following can only be attributed to the company as a whole (Boutan and Delsol, 1969). This explains why the input-output table (NA), which is itself broken down by branch, shows only the production and operating accounts.

The **Current Profit before Tax** (of the BA) includes the financial result (and therefore the financing choices), as it is calculated by deducting financial expenses (i.e. interest in particular), and adding financial income. This result is supposed to be stable if the investment and financing structure does not change over the years.

The **Primary Revenue Balance (PRS)**, which closes the primary revenue allocation account of the BA, corresponds to this GIS in that it describes property income. This includes the financial income and expenses (interest in particular) of the BA. However, there is a difference between NA and BA: dividends appear in this account. It also includes "rent on land and deposits", which companies pay to Households and General Government⁶³.

4.4.9. Redistribution: a government and Households approach

The NA redistribution account is a major departure from business accounting. Indispensable when adopting a national perspective on income, this account is largely constructed from the social administration accounts.

Even if the parallel is not very relevant, there is something in common between the company's net accounting profit and the next balance in the NA, **Gross Disposable Income (GDI)**. This is tax on profits, included in the "Current tax on income and wealth (D5)" account in the NA. GDI balances the secondary

⁶³Rentals for land (e.g. sharecropping) and access to deposits ('royalties') are distinct from rentals for fixed assets (buildings, machinery, etc.). While the former are income from ownership of non-produced assets, the latter are considered as purchases or sales of services. They are therefore included in Intermediate consumption (NA), in a similar way to the treatment of BA in external charges (United Nations et al., 2011, para. 7.153 et seq.).

distribution of income account, which also includes social contributions and other current transfers (e.g. non-life insurance indemnities, transfers between GGs, EU own resources).

Extraordinary BA income and expenses are not included as such, but are broken down into different NA accounts according to their type: fines and penalties are reclassified under "Miscellaneous current transfers" (D75), prizes and scholarships under "Social benefits other than social transfers in kind" (D62), capital subsidies under "Capital transfers" (D9) and disposals and acquisitions of assets under Formation or Consumption of fixed capital.

4.4.10. Savings, a concept that does not exist in the BA, but is similar to net profit for accounting purposes

Savings do not form part of the BA, but they do form part of the result of the NA, which means that they can be compared with the **net accounting result** of companies. This is calculated by deducting employee profit-sharing, counting exceptional items and deducting income tax. This is the company's accounting profit, which is influenced by all its strategic choices. It belongs to the owner-shareholders and corresponds to their remuneration.

In NA, savings are defined as follows: "that part of income from production, domestic or external to the country, which is not used for final consumption" (United Nations et al., 2011, para. 2.83). As companies have no final consumption, their savings are equal to their gross disposable income. For the other sectors (Households, General Government and NPIs), this consumption is deducted from GDI to calculate savings. This is a sort of bottom line for these players; it is what they can put aside to invest in durable goods, to repay debts or to lend (in fact, loans are made by financial intermediaries).

4.4.11. Statement of changes in equity, mirror of the cash flow statement

The NA accounts are similar in structure to the cash flow statement, which is calculated as the difference between the balance sheets of two consecutive periods. The BA statement is not an accounting document, but part of management accounting. Although the items are presented in a different order, the data used are very similar. The main difference between the two is the inclusion of Consumption of fixed capital in Changes in equity (whereas depreciation does not appear in the cash flow statement).

It should be noted that the NA does not rely directly on such a table constructed by business accountants, but on various elements: a "fixed assets table" and survey data for Gross fixed capital formation for the "classic" cases, and on other data for the more "atypical" cases (leasing, Households housing, agricultural and forestry sectors, etc.). (Hauseux, 2020; Magniez, 2009, p. 231).

Positive changes in asset stocks (**Gross fixed capital formation**, or investment) are estimated from accounting data on stocks. The values are revalued to market prices (the average price for the year). This requires assumptions to be made about "the regularity of inputs and outputs over the period, and the regularity of price movements". (Magniez, 2009, p. 251). A price index is therefore also used to smooth out differences over the year if inflation is high.

Consumption of fixed capital is the "decrease during the accounting period in the current value of the stock of fixed assets held and used by a producer, due to physical deterioration, foreseeable obsolescence or accidental damage that can be considered normal" (United Nations et al., 2011, para.

6.240). It is most often calculated by modelling, and differs from the depreciation used in BA⁶⁴. The main difference is that the company's depreciation is calculated on the basis of the historical acquisition cost of the asset, whereas the CFC is calculated on the basis of the market value of the asset in the current year (United Nations et al., 2011, para. 6.240). In practice, National accounting does not use business depreciation to calculate the CFC. In fact, companies deviate from "economic" depreciation rules to follow tax rules. These apply different rates to generate tax benefits (Richard et al., 2018).

National accounting then takes into account other changes in the value of assets and liabilities. These are not linked to transactions, but are nonetheless essential to the analysis. There are two types of accounts.

The first category corresponds to "**other changes in volume**", and includes developments that relate to changes in quality. There are three types of event. Firstly, the economic appearance or disappearance of natural resources. This account is used when they are discovered, or when they acquire or lose value in the eyes of the economy (increase in fishing or forestry resources, exploitation of a previously unprofitable deposit, etc.). Secondly, this account records "exceptional and unforeseen events that affect the economic benefits derived from assets" (United Nations et al., 2011, para. 12.9) for example natural disasters or wars. Finally, it records changes in the classification of institutional units or assets in the year in which such a methodological change occurs.

The second account brings together "**revaluations**", which are linked to changes in the level and structure of prices (inflation) that lead to "holding gains and losses" (United Nations et al., 2011, para. 12.3). These developments are linked to the price level of a particular good or service (leading to "nominal" gains or losses) or to general price developments ("neutral" gains or losses).

4.5. Stock accounts: conceptual differences, but compatibility?

Wealth accounts appeared later because of "the circumstances of the rise of the NA and the influence of Keynesianism [which] focused work on flows. The need to extend them to stocks was perceived, but the answer was postponed until later". (Vanoli, 2002, p. 381). Nonetheless, stocks are now a central element in economic analysis. They include assets (financial and non-financial) and liabilities.

⁶⁴ In business accounting, there are three concepts of depreciation, but the first is the one most often used (note that the tax authorities play on the life of assets and the rate of depreciation to give companies an advantage; the company specifies the choices made in the notes to the accounts):

1. Economic depreciation "is conceived as the allocation of the cost of the fixed asset over its probable life (i.e. of use by the business) so as to reflect the loss of physical and economic potential having regard to actual operating conditions" (Richard et al., 2018, p. 499). Annual depreciation is calculated by dividing the difference between the acquisition cost and the residual value (the estimated resale price at the end of use by the company; this is non-zero if the actual life of the asset is longer than the useful life) by the number of years of use. Depreciation is therefore straight-line, as it is impossible to estimate the actual wear and tear on the asset.
2. Static depreciation, which is estimated "based on an observation of changes in the potential resale value of the fixed asset concerned on a market" (Richard et al., 2018, p. 501). It is therefore more of a depreciation than a real amortisation.
3. Actuarial amortisation, which is "a loss in the value in use (present value) of the asset" (Richard et al., 2018, p. 502).

4.5.1. Definition of assets

We discuss two aspects in turn: the definition, based on theoretical considerations and linked to the function of accounting and the structure of other accounts; and the content of the asset, i.e. the typologies, what is retained and what is not. The quantification of these elements is not discussed again, as it has already been covered.

4.5.1.1. Theoretical design

The most theoretical discussion we have found of asset design comes from business accounting. We will therefore use it as a basis for discussion, as it encompasses what we have been able to read in National accounting. According to this theory (emphasis added),

"Assets correspond to what an accounting system recognises as the "things" available to the business for its activity (Wolk et al., 2013). Two concepts are regularly attached to the notion of assets, those of **resource** and **control**⁶⁵. [Ijiri (1967, 1975) defines assets as resources controlled by the company, a resource being, according to him, something that brings a profit and that comes from a **sacrifice** to obtain it". (Rambaud, 2015, p. 53)

Thus, from an accounting point of view, a resource is a means (Pallot, 1992) whose purpose is "to generate flows of money or to provide services" (Christiaens, 2004) (Rambaud, 2015, p. 54). The second point is that of control.

"The concept of control has evolved considerably since the 19th century^e. It has moved from a vision based strictly on ownership (Ijiri, 1967; Richard et al., 2011; Richard, 2005) to a more economic interpretation, where "the right of ownership is not essential" (IASB, 2010). In this view, what is important is "the capacity of an entity to control benefits" (IASB, 2010), which refers to control over the use of the resource." (Rambaud, 2015, p. 54)

If we now look at accounting standards, what do we find? IFRS retain the definition of resource and control, but do not take into account the idea of the sacrifice required to obtain the asset (Rambaud, 2015, p. 54). Donations can therefore be recognised as assets. The French Plan Comptable Général (French GAAP) uses a definition that is closer to IFRS than the one that prevailed prior to its 2005 reform. It defines assets as follows:

*"Art. 211-1 An asset is an **identifiable item of property, plant and equipment that has a positive economic value for the entity, i.e. an item generating a resource that the entity controls as a result of past events and from which it expects future economic benefits.***

This definition is also similar to that used in National accounting, with the notion of an asset controlled by an entity that is a source of value for that entity. Thus, in NA, assets include the notion of resource (in this case "advantage"⁶⁶) and control, but not that of sacrifice:

"An asset is a store of value representing a benefit or a series of benefits accruing to the **economic owner as a result of** holding or using an asset for a specific period. It is a **means of transferring value from one accounting period to another.**" (United Nations et al., 2011, para. 3.30./10.8.)

⁶⁵ (Christiaens, 2004; Ijiri, 1967, 1975; Meigs & Meigs, 1989; Pallot, 1992; Riahi-Belkaoui, 2004; Wolk et al., 2013)

⁶⁶ " 3.19. [There is an economic advantage when an action produces a positive gain or utility. This implies a comparison between two situations." (United Nations et al., 2011)

In National accounting, legal ownership⁶⁷ is of course recognised and corresponds to the majority of cases. However, for theoretical reasons, ownership in the economic sense⁶⁸ prevails in cases of doubt. In reality, ownership comes into play very marginally in certain cases where the two types of ownership are separated. Leasing is the most emblematic case.

Further, Rambaud (2015, p. 54) explains that there is a complementary conception of the asset:

"In parallel with this view of assets as a resource controlled by the company, there is another approach, based on a link between the different elements of the balance sheet. An asset is thus seen as a debit (Wolk et al., 2013) from the balance sheet that corresponds to a use of capital (Riahi-Belkaoui, 2004) invested. **An asset is therefore a use of present or future capital [...].** As demonstrated in (Rambaud & Richard, 2015b), these two approaches are not opposed, but represent two complementary visions of the notion of asset" (Rambaud, 2015, p. 54).

This concept, which consists of articulating the entire balance sheet around the idea of the use of liabilities, is not explicitly present in the definitions of the accounting standards cited. It is in fact found in the rules for recording assets, based on the double entry. This can be seen as more than a simple requirement for accounting consistency, but as the recognition of a causal link between the two entries.

There is no major difference between BA and NA. It should be pointed out that we are talking about the substance of the asset, or to put it another way, the material realities that accounting classifies as assets (machines, patents, etc.). We are not talking about the monetary quantification of this reality. We saw above, in connection with monetary valuation, that this valuation differed markedly between the BA and the NA, to the point of moving from one accounting model to another. This aspect is also reflected in the definition of assets in the idea of value (which calls for valuation at market price or NPV) or use (linked more to historical cost).

4.5.1.2. *Content and classification*

Once the theoretical definition has been established, we need to look at the content of the concept, i.e. the type of asset and the boundary between what is included and excluded in practice. As far as assets are concerned, there are no major differences between the BA and the NA, in line with what has just been said. There are, however, three changes compared with the BA accounts: R&D expenditure, military goods and artistic works. The first two, in particular, were the subject of debate in the 1990s. Vanoli's description clarifies the scope of the assets.

The inclusion of R&D expenditure in GFCF is enlightening for several reasons. He explains that at the end of the 1980s, National accounting staff "were still struggling to break away from a 19th century conception of investment and a rigid distinction between goods and services, the latter not being eligible for GFCF but only being incorporated into goods" (Vanoli, 2002, p. 388). He goes on to say that

⁶⁷ " 3.21. The legal owner of entities such as goods and services, natural resources or financial assets and liabilities is the institutional unit that is entitled by operation of law to the benefits associated with those entities. 3.22. General Governments sometimes claim legal ownership of an entity on behalf of the community as a whole. The SNA does not recognise any entity without legal ownership, whether on an individual or collective basis." (United Nations et al., 2011)

⁶⁸ " 3.26. The economic owner of entities such as goods and services, natural resources or financial assets and liabilities is the institutional unit that can claim the benefits associated with the use of these entities in economic activity by accepting the corresponding risks." (United Nations et al., 2011)

" 3.28. When General Governments claim legal ownership of an entity on behalf of the community as a whole, the benefits also accrue to them on behalf of the community. They are, therefore, both the legal owner and the economic owner of that entity." (United Nations et al., 2011)

they have accepted, in particular, the inclusion of expenditure on the discovery of subsoil resources, and on the production of software or films, because this results in a "visible" asset. For R&D, no "visible" assets are produced, hence their reticence. Finally, work on the economics of services has tipped the balance in favour of inclusion, because it "calls into question many of the characteristics traditionally attributed to all services: production on demand, simultaneity of production and consumption, absence of storage..." (Vanoli, 2002, p. 388). But the concept of GFCF remained incomplete in the SNA 93, according to Vanoli. This will be done in the 2008 SNA.

The debate on durable military goods brings up other points. Until SNA 93, all military expenditure, whether durable or not, is treated as current consumption and not as GFCF. The only exception is official housing. Armies do, however, count weapon systems and ammunition as assets. National accounting experts did not put forward many theoretical arguments. Stone justified this on the grounds of "the wide fluctuations in GFCF that would be generated in wartime". Vanoli explained that, because of their destructive nature, military durable goods obviously could not contribute to a conventional production process. In the end, first in the United States and then more widely, this expenditure was seen as contributing to a national defence public service, which justified the inclusion of military durables in GFCF and an asset account. Finally, the 2008 SNA will follow this example (United Nations et al., 2011, para. 6.232 & 10.144).

A third example of the difference between BA and NA, which is more marginal, concerns original artistic and literary works. It should be noted that "the intangible assets recorded by companies in their own accounts include many more items than those recorded under fixed assets in the national accounts". (Hauseux, 2020). For those that remain within the scope of the NA, they are not valued by the value entered on the balance sheet, but rather by the sum of production costs, which appears in the profit and loss account.

The few differences between BA and NA stem more from the classification of assets (Table 10). For example, the concepts of tangible/non-tangible assets have been eliminated in NA, while product/non-product classification does not exist in BA. Inventories are also much more developed in BA.

Table 10 Assets in National accounting and Business accounting

Corporate accounting		National accounting	
ASSETS		AN1	Produced non-financial assets
20.	Intangible assets	AN11	<u>Fixed assets by type of asset</u>
201.	Formation expenses	AN111	Dwellings
206.	Leasehold rights	AN112	Other buildings and structures
207.	Goodwill	AN113	Machinery and equipment
208.	Other intangible assets	AN114	Weapons systems
21.	Tangible fixed assets	AN115	Cultivated biological resources
23.	Assets under construction	AN116	Costs of ownership transfer on non-produced assets
27.	Other financial assets	AN117	Intellectual property products
280.	Depreciation of intangible assets	AN12	<u>Inventories by type of inventory</u>
281.	Depreciation of tangible fixed assets	AN121	Materials and supplies
290.	Impairment of intangible assets	AN122	Work-in-progress
291.	Impairment of tangible fixed assets	AN123	Finished goods
(same breakdown as for account 21)		AN124	Military inventories
297.	Impairment of other financial assets	AN125	Goods for resale
STOCKS & WORK IN PROGRESS		AN13	<u>Valuables</u>
31.	Raw materials (and supplies)	AN131	Precious metals and stones
32.	Other supplies	AN132	Antiques and other art objects
33.	Work in progress - goods	AN133	Other valuables
34.	Work in progress - services	AN2	Non-produced non-financial assets
35.	Inventories of products	AN21	<u>Natural resources</u>
37.	Inventories of goods	AN211	Land
391.	Impairment of raw materials (and supplies)	AN212	Mineral and energy reserves
392.	Impairment of other supplies	AN213	Non-cultivated biological resources
393.	Impairment of work in progress of goods	AN214	Water resources
394.	Impairment of work in progress of services	AN215	Other natural resources
395.	Impairment of inventories of products	AN22	<u>Contracts, leases and licences</u>
397.	Impairment of inventories of goods	AN221	Marketable operating leases
		AN222	Permissions to use natural resources
		AN223	Permissions to undertake specific activities
		AN224	Entitlement to future goods and services on an exclusive basis
		AN23	<u>Purchases less sales of goodwill and marketing assets</u>

In BA, there is an "asset frontier" that makes it possible to specify certain items that are not assets, although this term is sometimes used in everyday language. These are durable consumer goods (cars acquired by Households, for example), human capital and natural resources that do not have owners. The former are excluded because they are not mobilised for production ("the services they provide do not enter the production frontier"). Despite the idea that it is possible to invest in 'human capital', it is difficult to establish property rights over it, and quantifying it would pose even more problems. Finally, stocks of natural resources that are not the property of economic players are also excluded. (United Nations et al., 2011, p. 3.46-3.49).

4.5.2. Definition of liabilities

Now that we have studied the first side of the balance sheet, we can look at the liabilities.

4.5.2.1. Theoretical design

In BA, liabilities are made up of liabilities in the strict sense of the term and shareholders' equity. Regarding liabilities in the strict sense:

"Liabilities are what the accounting system recognises as a company's economic obligations (conventionally) to certain third parties (Riahi-Belkaoui, 2004). [... The IASB] also highlights the fact that liabilities are expected to result in a future sacrifice of resources (hence assets) for the enterprise." (Rambaud, 2015, p. 54)

"Broadly speaking, three characteristics constitute the 'essence' of liabilities (Riahi-Belkaoui, 2004; Wolk et al., 2013): the fact that a certain type of **duty** exists for the company; that this duty involves a **future sacrifice of resources**; and that this duty **arises from past or present events**."

Equity is discussed at greater length by Rambaud (2015), as it represents the actor who has power over the company (Richard et al., 2018, p. 258). Their definition is therefore much more subjective. Thus,

"Equity, on the other hand, reflects the presence of the company's owners/shareholders in accounting terms. Two main visions exist for understanding and defining this equity, both of which are linked to two points of view on the firm: the entity theory and the owner theory (Chatfield, 1977; J. R. Edwards, 1989; Müller, 2014; NN Mourik, 2010; Zambon & NNLT, 2000)." (Rambaud, 2015, p. 55)

According to the entity theory, equity is treated in the same way as any liability. This theory considers the company as an entity that exists in its own right and is ontologically separate from the providers of capital. Equity capital is therefore a due resource like any other. The owner theory, on the other hand, considers it to be residual, as the difference between assets and liabilities. This theory does not recognise the existence of the company itself, which exists only through and for the owner. Other liabilities are therefore separated from equity and reduce the value of the assets held by the owners.

In National accounting, it would seem that liabilities have received little attention, especially from a theoretical point of view. Economists, who usually bring these considerations to the NA, are primarily interested in assets. Liabilities are then obligations that reduce wealth, but rarely more. They implicitly use the owner theory.

So we can move straight on to the 2008 System of national accounts definition, which states the following:

"There **are no non-financial liabilities** recognised within the SNA; consequently, the term 'liability' necessarily refers to a financial liability by its very nature.

3.33. A **liability** is established when **one unit (the debtor)** is obliged, under specified conditions, to make a **payment or a series of payments to another unit (the creditor)**." ⁶⁹ (United Nations et al., 2011)

We note that there is no substantial difference between the liabilities defined for the two types of accounting.

Note to the reader: Thus, the following paragraph is verified in French, but may be wrong in English. Indeed, the concept of equity is different from the French "capitaux propres", in BA. Plus, it seems that translations mistakes appeared between the official SNA and its French version. As this touches the accounting theory and subtleties between the charts of accounts of different countries, more research is needed.

Vanoli (2002), on the other hand, takes the discussion of equity and wealth a step further. In the SNA, shareholder's equity does not exist as such. A "net wealth" is calculated as the total value of assets minus all liabilities, but it is only really similar to equity as defined above for... the institutional sectors of Households, Public Administrations and NPIs! Which obviously do not have an owner⁷⁰. For companies (financial and non-financial), net worth includes shares and other participations, which is the "capitaux propres"/equity found in BA. Because of the market valuation in NA, owners are therefore considered to have a "net worth of their own", in addition to their shares. Another way of doing this is to calculate the value of equity⁷¹ by deducting the value of the shares from the assets. This represents the total value held by shareholders (United Nations et al., 2011, p. 13.87)⁷². We then read that "13.90 Equity is the accumulation over time of retained and reinvested earnings." (ib.).

Finally, in relation to the entity and owner theories, the NA is ambiguous. It is obliged to record shares and holdings separately, but also proposes to estimate the total value they hold as the difference between assets and liabilities. This seems to be a compromise that maintains the two visions: that of the shareholder-securities holder and that of the shareholder-economic owner. These two points of view have been discussed, as indicated by Vanoli (2002, p. 419).

4.5.2.2. Content of liabilities

In BA, there are many liabilities. They are classified according to four criteria (Richard et al., 2018, p. 259):

- Origin. This may be external if the obligation arises from a legal commitment (e.g. an obligation to restore a site; a contract) or implicit. Its performance is therefore not dependent on the company. If the debt is internal, it depends on the company's decision: examples include the scheduling of overhauls of certain facilities, or shareholders' capital.

⁶⁹ Automatically, a receivable is created with the lender. "When one of these types of liability arises, there is a corresponding financial claim that the creditor has against the debtor. A financial claim is the payment or series of payments owed to the creditor by the debtor in respect of a liability." (United Nations et al., 2011, p. 11.17)

⁷⁰ This does not prevent the authors of the SNA from writing: "13.86. For General Government, Households and NPISHs, net worth is clearly the value of the unit to its owners."

⁷¹ "13.88 [...] This method makes it possible to calculate the value of capital in such a way that the net value is zero. Corresponding to the sum of assets minus the sum of liabilities other than shares, the result of this method of calculation is called 'equity'."

⁷² "Therefore, even if a company is owned in its entirety by its shareholders, it is considered to have, in addition to the value of its capital, a net worth of its own (positive or negative)".

- The irreversibility of the obligation. There are several types of reversible obligations. They may be probable, possible or uncertain (i.e. not probable).
- The determinability of the obligation: this involves being able (or not) to determine the amount or the date of performance.
- Assignability of the obligation: sometimes it is not possible to know who the beneficiaries are. The classic case is that of redundancy plans.

Historical cost accounting covers a wide range of debts, both internal and external. However, the principle of prudence means that uncertain external debts are excluded. Probable or possible external debts are retained on a case-by-case basis according to their probability and, therefore, the accountant's prudence. Reversible internal debts only appear if they are probable (i.e. highly probable in practice; these are provisions for charges) (ib.).

The liabilities in the Plan comptable général (French GAAP) are very broad:

"1 A liability is an item of property, plant and equipment with a negative economic value for the entity, i.e. an obligation of the entity to a third party that is probable or certain to result in an outflow of resources to the third party, without at least equivalent consideration being expected from the third party. All of these items are referred to as external liabilities.

2. This obligation may be legal, regulatory or contractual. It may also arise from the entity's past practices, its stated policy or sufficiently explicit public commitments which have created a legitimate expectation on the part of the third parties concerned that it will assume certain responsibilities.

3. The third party may be a natural or legal person, whether determinable or not." (Autorité des Normes Comptables, 2019, arts. 321-1)

Debts are then defined as "certain liabilities whose due date and amount are precisely fixed", while a provision is "a liability whose due date or amount is not precisely fixed."

In the 2008 SNA, the liabilities used are legal liabilities and implicit liabilities⁷³. Contingent liabilities are not included. These are liabilities that are the subject of a contract, but which are only paid if specific conditions are met⁷⁴. This conditionality excludes them. Provisions⁷⁵ are also excluded, for the same reason, but also because they are not the subject of a legal contract. For National accounting, this involves allocating funds to a specific function, but these remain in the company's net worth.

Finally, the liabilities of the NA appear more limited than those of the BA, which brings it closer to model 2 (owner's theory).

⁷³ "A long-standing and widely approved practice that is not easy to refuse. Some payments made by General Government to individuals fall into this category" (United Nations et al., 2011, para. 11.16)

⁷⁴ "Some liabilities may involve a legal contract, but specify that one party is obliged to make a payment or series of payments to another unit only if certain specified conditions are met. These liabilities are called contingent liabilities. Generally speaking, the SNA includes (legal) liabilities and implicit liabilities, but not contingent liabilities." (United Nations et al., 2011, para. 3.40)

⁷⁵ "A company may set aside funds to cover unforeseen events or customer defaults." (United Nations et al., 2011, para. 3.41)

5. Methodological perspective: overview of the "transition to accounts" and the role of modelling

The historical perspective has enabled us to understand the origins of the NA structure and the different concepts used. The conceptual comparison provided a more detailed description of the translations of business accounting made by National accounting.

We can now see how business accounting is used today as a source of data by statisticians. What is its place among other statistics? How do national accountants combine their observations with sets of assumptions that add a dose of modelling to the accounts? This second question is important for this thesis, as it has been a major topic of discussion in the environmental field, as we shall see in Chapter 3.

5.1. Business accounting, an essential source of information

The NA has developed in two directions. Some countries (notably the United States and the United Kingdom, with Stone) have taken a top-down approach, disaggregating major aggregates. These systems use only tax data as a source of information. Conversely, the Norwegians, the Dutch and, above all, the French have preferred a bottom-up approach. The information comes from tax data.

In France, the concrete link between the NA and the BA took the form of a "company intermediary system" in the 1990s. This is a micro-macro transition information system. It is based on the reorganisation of BA items according to a more general structure, showing in particular value added. This leads to publications by activity sub-sectors which aggregate these accounts. To move from the intermediate enterprise system to the higher level, these sub-sectors are used, along with conversions of accounting nomenclatures, adjustments for tax evasion and cross-checks with other institutional sectors and the IOT (Vanoli, 2002, p. 216). It has now been replaced by INSEE's internal information system, [Esane](#). "The organisation of financial information in business accounting makes it difficult to extend the IS to the financial account, which resists the micro/macro transition" (Vanoli, 2002). (Vanoli, 2002).

As detailed very well by Dufour (2019) the construction of the NA tables consists of bringing together various sources and filling in the boxes one by one, then end to end, checking the overall consistency. Muller (2019) also explains the transition from company accounts to national accounts, highlighting the various stages and difficulties involved. Three types of correction are made: conceptual corrections (as we have seen above), corrections to ensure consistency between sector accounts (reconciliation and arbitration between sources), and corrections for completeness (additional data). Company data is of high quality. They therefore carry more weight than other sources, and the entry point for constructing the French accounts is the income approach. The production approach is also based on these data. The demand approach, on the other hand, is based on estimates of value added.

The construction of National accounting tables cannot be based solely on the accounts, which do not cover many fields of observation (Table 11). National accounting also relies on data from the rest of the official statistical service and other internal resources. For example, the Banque de France provides financial data and the Directorate General of Public Finances provides government accounting data. On the other hand, the ministerial statistical services of the Ministère de la Transition écologique provide data on housing, while the Ministère de l'Agriculture provides data on its sectors.

Table 11 National accounting sources and statistics (source: Mahieu, 2019)

Institutional sector	Complete and exhaustive accounting	Complete and restated accounting data	No accounting data used
Non-Financial Corporations		Non-agriculture non-Financial Corporations	Agriculture, forestry, fisheries Housing Social action
Financial Corporations	Financial intermediaries Insurance	Financial auxiliaries	Housing
General Government		Public administrations	Housing
Households		Non-agriculture quasi-corporations	Agriculture, forestry, fishing (including own consumption) Construction, housing, domestic services
NPISH			Social work Various activities

Survey sources may appear more reliable for certain sectors, particularly agriculture (Mahieu, 2019) or for certain items (production for own final use, leasing). As for input-output tables, the other NA table, final consumption, imports and exports can only be based on surveys or customs data.

5.2. Accounting, descriptive models between observation and assumptions

The principle of true and fair view is often described in business accounting. At first glance, it can be said that it exists in both types of accounting, but that it has its limits.

In the BA, it is relative on two points: the estimation of depreciation and provisions for risks, which leave a large part to estimation and modelling. Depreciation, which is supposed to reflect the wear and tear on assets, is based on the average life of the assets in question. An assumption has to be made on this point. Provisions for contingencies correspond to setting aside money to deal with a risk that may arise in the future, without this event being proven or the amount being known in advance.

At National accounting level, the subject is naturally more delicate, because the national accountants do not have any material evidence (invoices, contracts, etc.) to prove that the transactions actually took place. The NA does not record transactions in the BA sense, but observes the economy. However, observation of such a complex object cannot be perfect. National accounting necessarily makes debatable choices, which may amount to modelling. If the observer's choices influence the representation produced, users can legitimately criticise the quality of the figures they receive. This can be a problem for a statistician who adopts a realistic stance: the objects and concepts it observes pre-exist it and it is not supposed to interfere with them during observation (Desrosières, 2008a).

The subject was well introduced by Vanoli (1998) following the debates on environmental extensions (see chapter 3 for details of these discussions).

"In general, modelling attempts to analyse 'what would or could happen if...? ?'. It is conditional and hypothetical. By its very nature, modelling cannot provide a single answer. Differences in the basic structure, parameters or exogenous assumptions lead to different

answers. Different models give different answers and a given model may produce different variants.

Accounting for a past period (ex post accounting), on the other hand, aims to provide a single, direct answer to the question "what actually happened" [...] Ex post accounting is based on real observations, facts or data. A priori, the object to be measured exists, or has existed. It is, or has been, observable. This is certainly not the case with accounting for the future or simulating various states of the economy. The object to be measured is then conditional and hypothetical.

To find the junction between these models and accounting, we need to look at the definition of the term model. It has a wide variety of meanings (CNRTL, n.d.) A model is a substitution considered to be representative of something. This is often simplified; the model can also be an example of the thing. To be a little more concrete, we can use the definition used in epistemology⁷⁶:

ES: "physical, mathematical or logical system representing the essential structures of a reality and capable at its level of explaining or dynamically reproducing its functioning". (CNRTL, n.d.)

The creation or choice of a model follows a reductionist logic, because it must resemble the thing while simplifying it. The model is therefore not the thing itself, and some of its characteristics are different. Finally, the behaviour of the model corresponds to that of the thing to a *certain extent* (within a domain of validity).

Models can be physical, abstract or conceptual in nature. Examples of the first type are: "ideal" individuals supposed to represent a group; a prototype; a person posing for a painter; in pharmaceutical tests, mice are used as models of humans. In the second category, we find mathematical expressions, drawings and logical relationships, which can sometimes be combined in very elaborate sets.

The objectives of the models are a capital distinguishing feature for our work: the models can have a descriptive, explanatory or predictive vocation (Bartelmus, 2014; Legay, 1997).

In the light of this diversions, we can see that accounting does indeed meet the generic definition of a model: it is a simplified representation of a company or an economy. This representation is static and is based on figures placed side by side in a table. Accounting is thus an archetypal *descriptive* model, which makes it both similar to and clearly distinguishable from the scientific exercises commonly referred to as 'modelling'. Accounting is not explanatory, predictive or dynamic, and it is not made up of mathematical expressions (although its construction may require them).

We can now return to National accounting and study the various forms of "models" that concern it (Table 12). As Vanoli (1998) points out, if the study of the future is necessarily based on (predictive) models, it is worth asking whether the observation of the past is based solely on observations.

It is not possible to individualise events and keep supporting documents at the heart of the BA. In the absence of perfect data, National accounting staff have to make quantification choices on a regular basis. Contradictory sources for the same figure, difficulties in respecting accounting balances based

⁷⁶ With reference to the linguistic dimension of accounting, it should be noted that linguistics also uses the term model. It refers to "an abstract, rigorously axiomatised construction that can be used to formulate a linguistic theory".

on the multiple sources used and missing information regularly require adjustments or arbitration. Statistical estimation methods themselves produce models, based on samples whose characteristics are extrapolated to the complete population (a sub-group *representing* a larger group). Admittedly, we can estimate the probable error, which enables us to adjust the degree of confidence we place in the final figure. But there remains a fundamental difference with an exhaustive census.

This type of modelling is most often accepted, because the work of the statistician or national accountant is based on the assumption that what he is measuring, or quantifying, exists (Vanoli, 1998) in line with a realist perspective (Desrosières, 2008a). It does indeed represent an economic fact, even if it escapes its gaze in part. This is true of the 'observation' of economic facts traditionally recorded in accounting. Whether this source is used directly (as in France) or indirectly (through surveys or tax packages), we remain in the realm of observation.

Table 12 Between modelling and observation, a gradation of accounting approaches

Type of object	Hard modelling	Soft modelling	Statistical models	Internal budgeting	Transaction accounting
Examples	Macroeconomic modelling	Allocations, constant prices, CFC	Sampling, reconciliation, adjustment	Provision	Buying, selling, accounting debt
Transaction	No	No	Yes	No	Yes
Economic fact	Virtual	Real	Real	Possible	Real
Who produces the numbers?	Statisticians and national accountants			Corporate accountants	
Confidence granted by statisticians	Low	Intermediate	High	Low	High
Relationship with national accounts	Out of scope	Inclusion on a case-by-case basis	Accepted	Out of scope	Observed

One case debated by National accounting is that of provisions (de Haan, 2022; Lequiller, 2004). Should they be disclosed? Are they a genuine economic fact, significant from the point of view of the behaviour of the company and its stakeholders? We will discuss this point later (on liabilities), but we can already see that the difference with the rest of accounting is that this is an internal budgeting exercise. It does not therefore require validation by an external party, and it is not a transaction with the outside world. As a result, potentially significant or inappropriate assumptions may be made by the company regarding the probability of the risk or the amount to be provisioned.

Next come the so-called soft modelling exercises, which take greater liberties with the primary sources. These are virtual operations, defined by national statisticians and accountants. The most classic cases are: production of housing services measured by imputed rents, calculation of financial intermediation services and insurance premiums, actual Final consumption expenditure reflecting the share attributed to government of certain services produced. Some of these operations can be based on a physical reality, which provides a relatively solid basis for quantification. This is the case for imputed rent. Insurance premiums and banking intermediation services, which correspond to the output of these sectors, are not individualised in the individual accounts. National accounting therefore has to estimate and impute this output by extracting part of the amount of interest. National accountants are reluctant to do this, but feel obliged to accept these deviations from pure observation:

"Since some aspects of reality are not directly observable and excluding them from the central national accounts would give a distorted picture of the economy, there is no alternative but to accept a certain amount of 'soft modelling'." (Vanoli, 1998, p. 358)

The correction of values to obtain constant prices is a modelling exercise of this type (ib.). These corrections are useful for analysis (as they allow values from different periods to be compared), but they are based on different methods. Since a single figure cannot be estimated, this means that the statistician must make a choice of representation.

Consumption of fixed capital at national level is the subject of a real modelling exercise. It is calculated for each type of asset, each industry and each institutional sector on the basis of four elements:

- The observed stock of assets, or more precisely, of a long series of investments in the economy,
- The estimated or observed useful life of the assets,
- Estimation of the probability of asset disposal (following a lognormal distribution), i.e. the cessation of asset use,
- A "depreciation" law that simulates changes in asset prices as a function of their age (linear or geometric depreciation) (Hauseux, 2020; Vanoli, 2002).

Here, the assumptions are based on the impossibility of knowing the actual stock of assets at a given point in time (hence the probability of stock removal), and also on the rule to be applied for wear and tear (estimated useful life and type of depreciation).

Net present value (NPV) is a subject of debate among national accountants. It involves estimating the future income flows that will be generated by certain assets, the value of which cannot be estimated in any other way. This is the case, for example, with mineral and energy resources still present underground. The calculation therefore involves assumptions about income flows and a discount rate. The discount rate has a major influence on the final result, since it "crushes" the most distant flows in time. In other words, the entire NPV is based on strong assumptions. Business accountants cannot use this method of calculation in their accounts either, for the same reasons (although IFRS allow it, national accounting standards exclude it) (Richard et al., 2018; Suzuki, 2010). In National accounting, this concept can be used, but only as a last resort because of the assumptions required. This method is still mentioned because of its theoretical (neoclassical) basis, according to which it reflects the true value of the asset in perfect markets.

Finally, predictive modelling exercises or stylised explanatory models are excluded from National accounting. They are based on very significant simplifications that make it impossible to represent the diversity of economic operations (facts?), or on strong assumptions that strongly condition the values produced. They include various economic modelling exercises and econometric prediction models.

What is not said by these authors, but which seems to us to be absolutely key, is the position of the producer of the data in relation to the economy itself. Is it inside or outside the economy? This determines whether the figure produced has an effect on the behaviour of the economic player it relates to (the company, the Households, etc.) and on the relationships it has with other players (stakeholders, etc.). This idea is linked to the performativity of information systems (Espeland and Stevens, 2008). As we saw in Chapter 1, accounting organises the relationships between players by mobilising four functions: counting, recording in accounts, reporting and being accountable (Stolowy et al., 2010). Thus, all published information has microeconomic effects. On the other hand, the

imputations made by statisticians have no *direct* effect on the economic players themselves. Adjustments even less so, because they are unknown to ordinary mortals.

This point can be put slightly into perspective by considering that NA has performative effects on economic players, as is the case, for example, with the announcement of inflation forecasts or central bank key rates on the financial markets. National accounting provides an overview of the general and sectoral economic environment in which companies operate. The observation of a change in this context may prompt them to modify their behaviour. That said, the effects are less direct than the publication of their own accounts. Moreover, the distinction between the production of figures within or outside the economy remains key (at least implicitly) in the ethical positioning of National accounting and the quality criteria they apply.

6. Discussion

After following the development of national accounting and its harmonisation over several decades, Vanoli describes the peculiarities of what might be called national accounting schools. Although it was not intended to do so, it appears that this chapter is perfectly in line with the French national accounting tradition. This tradition has distinctive features that are not to be found in what he describes as the Dutch, English, American or Scandinavian schools. He uses the term school, specifying that they are not associated with any real militancy, but that a network of historical influence is nonetheless perceptible.

"At the same time, and this is the fourth salient feature [of what would be a French school of NA], the central framework is itself conceived entirely as a complete system of integrated stock-flow accounting. The reference to business accounting is very present both in the concrete implementation of the use of accounting sources (from which the idea of the intermediate system as the inevitable link in the micro-macro transition derives over time) and in the way of reasoning. This very last point is perhaps more difficult to grasp. It means that, while thinking about the accounting framework as a whole (for example, the future SNA 93) or about how to deal with this or that particular event, we do not place ourselves narrowly in the context of a set of boxes to be filled in (although this operation must take place), but from the point of view of an accountant who would have the effective possibility of carrying out directly and immediately, for the economy as a whole, the primary recording of the events that concern it. From this point of view, we reason as if, at any given moment, the balance sheet accounts (assets and liabilities) were established, the transactions or other flows that cause them to vary were recorded and the revaluation of assets and liabilities was carried out. The accounting system is a whole, and all its parts may be called upon to play at the same time. This is not necessarily how national accounts are estimated ex post, but it is how the system is thought of ex ante in this approach. This culture and approach hardly seem to be found elsewhere with the same intensity". (Vanoli, 2002, p. 581)

Our position is very similar, although this is rather related to the starting point of this thesis. It stems rather from a naïve approach to National accounting and the polarisation of our study by the work, prior to this thesis and very rich, around the Business accounting model CARE. But it turns out that this accounting perspective on NA opens up some very interesting avenues of innovation in the field of environmental statistics. These are summarised in Table 13 which we describe below.

6.1. Historical and methodological perspectives

By combining historical and methodological perspectives, we can draw a number of lessons for designing environmental accounts.

The first is the mutual influences of BA and NA, which can be reproduced. Business accounting was first used tacitly to define some of the fundamental macroeconomic variables (income, assets, liabilities). Economists added new concepts, linked to Households (savings) or public administrations (redistribution) for example, or because of their "overhead" view of the economy (inflation). The accounting framework was also used to integrate a wide variety of statistics in a coherent way. The aim was to provide a detailed analysis of imbalances. By taking the connection with the corporate level very far, the French hoped to capture the full complexity of economic operations. The very construction of such an NA was almost intended to mimic the gradual development of real prices (Miller, 1986). Many countries have not gone so far as to construct intermediate company accounts like the French, but this experience nevertheless invites us to consider the following idea. Changes in

business accounting have an influence on the behaviour of individual players and on the structure of the economy. Thus, constructing an NA based on principles that are very different from those of the BA would open up the possibility of failing to grasp the realities of the economy.

In return for this conceptual inspiration, French national accountants have influenced Business accounting: the profit and loss account was modified following the reform of the *Plan comptable général* (French GAAP) in 1982 to facilitate the calculation of Value added and Earnings before interest, taxes, depreciation, and amortisation. This may also be necessary for the environment.

Table 13 Chapter summary

Links	Economic accounting	Contribution to environmental NA
Mutual influences	Construction of the NA inspired by the BA Changes to the <i>Plan comptable général</i> (French GAAP) for calculating value added and EBITDA	Encourages the firm anchoring of environmental NA in the BA and in one of its environmental extensions
Conceptual exchanges	NA accounting principles have been retained (accounts, double entry, structure similar to the P&L statement and balance sheet), but new accounts have been created (changes in assets, redistribution and consumption). New concepts in NA: savings, net worth, capital transfers, final consumption, redistribution, etc. A common vocabulary (production, assets and liabilities) and related concepts (CFC/depreciation, payroll/salaries, intermediate consumption/purchasing costs) Monetary valuation: identical for cash flows; market value (NA) VS historical cost (BA) for inventories	This raises the question of the creation of new accounts linked to a strictly env. logic (physical accounts?) Authorise translations of business accounting if the need arises. Indicates the innovation framework and the possible deviations for each concept (asset, liability, etc.). Monetary valuation deserves a more in-depth theoretical analysis, but we can already see that a translation of CARE may be necessary for stocks. How can this be done while maintaining the same theoretical underpinning?
Data exchange	NA relies heavily on accounting observation. There are no such strong links anywhere else in the world.	In the absence of accounting data, which sources should be used? Are there any protocounting sources? How much modelling is acceptable in this emerging field of statistics? Can the statistical bodies afford a more relative level of quality to begin with? Should other types of public administration be involved instead?

This section gives us a better grasp of the importance of the historical and situated dimension of the accounting construct. Accounting has become so sedimented in people's minds that it can be wrongly

regarded as a timeless, anhistorical technique that has always been present in the same form. This leads to a number of difficulties in designing new accounts for the environment. For example, it is possible to take too literally what we call the "accounting constraint", i.e. the need for innovation to be consistent with what already exists, and in particular with standardised frameworks. This is not to say that we should propose changes without understanding the choices made in the past. On the other hand, integrating a subject as new as the environment requires us to define a long-term transformation horizon that may involve profound changes to the framework.

It also seems important to take a step back from the quality requirements of the environmental accounts that might be produced in the short term. In the 50s and 60s, the data produced was of poor quality, according to the producers. This did not prevent them from being widely used as a basis for discussion, as a tool for coordination, or for government. (Chiapello and Desrosières, 2006b). Later, public criticism emerged about the mixing of past and forecast accounts. A series of corrections were in fact made to the one based on the other. National accounting then changed its practices (Fourquet, 1980). But this can be interpreted as a shift from a use of coordination to a more marked use of "proof", i.e. the description and demonstration of an external reality. This shows that it is possible to compromise on the metrological quality of quantifications if the tool proves particularly useful.

That said, the current institutional organisation of statistics clearly separates the production of figures from their use. This is due to the considerable weight given to the requirement for statistical quality, a sign of the confidence that can be placed in the quantifications produced. We must therefore be wary of trying to reproduce exactly this organisation in environmental accounting, which is nearly fifty years less mature. This would seem to apply to the division of roles between research and the various General Governments in the design, production and use of the accounts. We should not expect experiments in environmental accounting to be any better than the first economic aggregates of the 1950s. Nor should they be produced by traditional statistical services from the outset. Instead, as was the case after the war, they could be produced by services at the heart of the action (for example, public policy design or evaluation, planning), equipped with new information bodies dedicated to them.

6.2. Contribution of conceptual comparison

The results of this chapter justify using BA as a basis for an environmental extension of NA for several reasons. As the conceptual basis of economic NA, BA offers implicit support that may have been forgotten or never discussed, either historically or in the other pillar disciplines (economics and statistics). (Chiapello and Desrosières, 2006b). Special attention must therefore be paid to the accounting discipline. It seems essential to go through this field to avoid making mistakes in its fundamentals. Secondly, a particular feature of the axiomatic of French NA leads us to base our work on BA: this can be considered as accounting for the accounting of organisations, unlike Anglo-Saxon NA, which is an accounting of flows (Arkhipoff, 1984). The latter can certainly do without BA epistemologically, while remaining a representation of the economy within an accounting framework (Archambault et al., 1986). But an accounting of accounting can probably do less without it.

There are, however, valid arguments in favour of relativising the role of the accounting discipline in what is now the NA. First of all, its scope - the national economy - is not the same as that of business. Specificities have emerged that justify changes in methodology. Secondly, other disciplines (notably economics) jointly propose interpretative frameworks and theoretical foundations which may compete with those of accounting theory and imply different methodological choices. Here, however,

we need to distinguish between two aspects: what is really required for macroeconomic analysis, and what is the historical and contingent introduction of certain ideologies. In the first case at least, a scientific discussion can be opened to make informed choices between economic and accounting proposals. This chapter shows that such a discussion has probably never taken place. There are gaps in the sources used, which means that we must remain cautious. But it has to be said that past discussions, as recounted by Vanoli, Fourquet or Desrosières, did not involve accounting theory. The result is a certain vagueness and irreconcilable, sometimes inexplicable positions, even according to Vanoli (2002). He has, however, been able to synthesise the rich discussions surrounding the notions of wealth, assets, capital, income, the volume-price split and its interpretation, etc. The arduous debates surrounding types of monetary valuation and the inclusion or exclusion of certain assets would have greatly benefited from being placed in the context of clearer conceptions of capital, historical accounting models and theories of the firm.

Moreover, the environmental extension of NA would also benefit. As explained, it has not yet been possible to translate business accounting theory into NA. This should be the subject of future research. A starting point would be to draw on texts written by NA theorists (Archambault et al., 1986; Arkhipoff, 1984; Vanoli, 1986; Wolf and Femia, 2022)..

Even without this, the comparison of accounting concepts makes it possible to sketch out and lay the foundations. For example, the discussion of liabilities shows that there is no such thing as a non-financial liability. This leaves the field wide open for creating them. BA and NA liabilities are very similar in definition and content. The challenge will therefore be to define environmental liabilities rigorously, and above all to delimit them. Past approaches, such as defensive spending or certain indicators designed to exceed GDP, have failed on this point. They were not based on sufficiently rigorous definitions and opened up an infinite field of quantification. In the case of defensive spending, the concept called for all spending considered to be negative or to reduce well-being to be subtracted from GDP. It will therefore be necessary to specify conditions for inclusion and a relatively clear boundary for ecological liabilities, similar to the production boundary or assets found in the SNA. In addition, the exclusion of internal liabilities by the NA will have to be respected, and a third party will have to be found to guarantee the definition of capital and to claim reimbursement. Finally, a quantification method that relies as little as possible, at least in the long term, on modelling will have to be mobilised.

The question of the individualisation of environmental expenditure in GDP is raised by the CARE model. This model separates conservation expenditure from the rest of a company's activity, which corresponds to the operating and production cycle. While it is not unreasonable to distinguish preservation expenditure from other Intermediate consumption, what place should be given to it? Should they also be excluded from the production account?

As far as the assets are concerned, the specifications appear to be less onerous: the substance and scope of the assets in BA and NA are virtually identical, and the differences do not seem to pose any problem for our translation of the CARE model. Once again, we will have to be able to systematise the definition of CARE's natural assets in a rigorous and delimited way. While liabilities are already relatively well defined, assets have received less attention in CARE's research programme. They will therefore require more work. Next, they will have to be classified according to standard typologies at company and NA level. Will they be tangible assets or not? Products or not?

Monetary valuation is a delicate subject. It lies at the heart of accounting theory. It is closely linked to the concept of capital (as money, fund or material capital), and to that of the company (according to the owner or entity theory). It has a very strong effect on the accounting result, and therefore on the

dividends that may or may not be paid, and on the management trends that may be adopted (exploitation of a resource or sustainability). Net present value is therefore quite radically opposed to historical cost. The market valuation position, which may seem intermediate, in fact conceals a conception of the company that is very much its own: that of the banker, rather than that of the shareholder-owner or company manager. For Chiapello and Desrosières (2006) the question of monetary valuation is also relevant to the actor acting on a macroeconomic scale. They explain that favouring cost accounting is more in keeping with the logic of the engineering state, while present value accounting is closer to neo-liberal states⁷⁷. Here, the clearest choice is between retaining something akin to historical cost for valuing assets, or moving to market prices. In the final analysis, the aim is to remain faithful to the conception of the CARE model, or at least to some of its essential characteristics, which guarantee support for the ecological transition towards a highly sustainable economy.

⁷⁷ The table given in the introduction to Chapter 1 can be used to identify the differences between these types of state.

Chapter 3 - Monetary valuation in the history of the SEEA: hesitations between strong and weak sustainability

Note: sources marked with a code (such as LG/5/pro or UNCEEA/6/6) are the primary sources for this work. In accordance with historical practice, they are dealt with in a separate 'primary sources' section of the academic bibliography. The academic bibliography corresponds to the secondary sources that support the general reflection.

Summary

The System of national accounts has been developed over the last thirty years to better reflect the relationship between the economy and the environment. In 2012, a statistical standard was created in this context: the SEEA Central Framework. The physical accounts for ecosystems also became a standard in 2021, and the monetary accounts obtained the status of "internationally recognised statistical principles and recommendations". Our article examines the history of the standardisation process from 1993 to 2021, focusing on the debates surrounding monetary valuation. Although some of the experts involved in the process have written their personal analysis of a given period or issue, none has described the thirty-year process in detail. Yet understanding the evolution of the controversies around monetary valuation and how the institutional process shaped them sheds new light on current debates. Through the prism of controversy analysis, this article reviews the different versions of the SEEA, most of the documents from the London Group and UNCEEA meetings, and some related academic papers. Interviews with experts involved in the process complete the picture. This makes it possible to draw up a general history of this process of creating statistical standards. Four controversies are analysed in detail: monetary or physical accounts; framing of assessment by cost or damage; modelling or observation; and ways of integrating environmental and economic accounts. We show that the choices made in the SEEA are mainly the result of rational arguments, general trends in environmental economics, institutional considerations and individual trajectories. Overall, this shows how there has been a gradual shift from a system designed primarily to preserve the environment itself to one devoted to valuing the benefits of Ecosystem services for the economy.

1. Introduction

The System of economic and environmental accounts (SEEA) is the most important forum for exchange on the subject of extending national accounts to include the environment. This process, which brings together national accountants, economists and environmental experts under the aegis of the United Nations, enjoys unrivalled institutional legitimacy. The recent publication of the SEEA ecosystem accounts ecosystem accounts (United Nations, 2021) offers new hope for overcoming the limitations of GDP and its underlying accounts, and reconstructing national accounts in which the environment (and ecosystems in particular) will be better integrated. This would enable public policies and decisions to take better account of the environment.

However, accounting systems are not neutral. Whether at national or company level, they are a place where controversy crystallises, because they require, among other things, rigorous definitions, the choice of quantification methods and a high degree of internal consistency. The accounting conventions adopted reflect a particular vision of the objects it measures. National accounting, for example, synthesises the views of economists, statisticians and accountants (Vanoli, 2005). National economic and environmental accounting broadens these points of view by involving ecology, physics and geography. To find out more, Desrosières (2008a, 2008b) has shown that it is strongly rooted in visions of public action and philosophical considerations. This means that the conventions adopted are profoundly political.

An examination of the four versions of the SEEA, from 1993, 2003, 2012 and 2021, shows that the quantification of the environment has been the subject of several competing proposals that can be schematically linked to weak or strong sustainability (Dietz and Neumayer, 2007). Biophysical approaches are traditionally associated with strong sustainability, while those based on monetary valuation of damage (in particular through the concept of genuine savings) are associated with weak sustainability. Between the two, the estimation of the costs of achieving environmental objectives raises a question: although monetary, it is classified in the approaches linked to strong sustainability. However, there have been contradictory developments in the design choices made for the SEEA. On the one hand, the biophysical accounts are increasingly detailed and highlighted, which brings the system closer to the concepts of strong sustainability. On the other hand, monetary accounts have evolved from the idea of constructing a green GDP based more on the costs of maintaining the environment in its current state (Statistics Canada, 1994; United Nations, 1993a) to that of considering ecosystems as sources of value, whose degradation would be expressed as the loss of Ecosystem services (United Nations, 2021). In so doing, we are witnessing a shift from an ambiguous vision of sustainability to a clear focus on weak sustainability.

This article sets out to explain this particular development by examining the debates within the community that developed the SEEA and the external influences that shaped it. Being both technical and prescriptive, the SEEA involves various figures in a process that reveals their positions on many issues. It was their meeting that led to the current system.

This raises a number of questions. What type of player was involved in the process, and what role did they play? What approaches were imported from disciplines other than National accounting? How were they received by the other experts present, and how did they fit into the accounting system?

Several experts more or less closely involved in the SEEA have written a few paragraphs or pages on the history of the subject, going further than the period of their own work (Alfsen and Greaker, 2007; Bartelmus, 2014, 2006; Brandon et al. 2021; Edens and de Haan, 2010; Hecht, 2005, pp. 9-15; Norgaard, 1989; Obst, 2015; Pasquier, 2010; Vanoli, 2005; Weber, 2018). They describe the important

stages and technical controversies, sometimes taking a stance in favour of one approach or criticising certain aspects of the process. To our knowledge, only one historian has worked on environmental accounting (Bérard, 2019). He presents very clearly the evolution of the broad outlines of the SEEA and the international programmes that have contributed to it, up to 2016. It mentions some key debates, but does not go into detail.

Thus, this chapter appears to be the first to focus specifically on the history of the SEEA, from its origins in the 1970s to 2021, the date of publication of the latest standard. Furthermore, in order to understand what has guided the conceptual choices of the SEEA monetary accounts, it goes much deeper into the making of this accounting system and the main debates that have animated the community. Given the complexity of the subject, we have mobilised frameworks for analysing controversy (Lemieux, 2007; Seurat and Tari, 2020). This chapter also draws on sources that have never been used for such a long history: all the documents discussed at meetings since 1994, sixteen interviews with experts present throughout the three decades, and academic articles.

The outcome of a process of this nature is linked to a number of different factors: power factors and argumentative constraints (Lemieux, 2007). It is necessary to disentangle these two effects, by analysing in detail the institutional process, the strategies of the players and the power relationships, but also, in a second stage, the arguments mobilised by each camp.

To understand the power relations between experts and to introduce the subject, we will begin by presenting the institutional context of the construction of the SEEA. This will enable us to identify the key periods.

Next, we propose a stylisation⁷⁸ of the sub-controversies identified as the most central. The identification and precise definition of these more local debates are in fact the result of conflicts that have gradually taken shape. It is therefore an a posteriori synthesis that will be presented.

We then go into the details of how the monetary accounts were produced, describing the key moments that were identified. This will be an opportunity to describe the discussions that took place between experts and led to major conceptual changes. In this way, we will see how sub-controversies opened up, re-emerged or disappeared as the debates and the generations changed.

In the final section, we will come back to the salient elements of the whole process, before answering the general question of this chapter on sustainability. The conclusion will describe the contributions of this work to the thesis.

Readers are referred to the Appendix F and Appendix G to find your way through time and the different versions of the manuals.

⁷⁸ In the form of a sentence reflecting the main idea being defended. This simplifies things, of course, but it also brings together the arguments for and against each approach. What's more, a sentence allows the definition to be more nuanced than a single expression.

2. Concepts, materials and methods

2.1. Analysis of controversies

Our definition of a controversy is as follows: "a situation (1) in which a dispute/disagreement (2) between several parties (3) - each party engaging specialised knowledge (4) and none of them being in a position to impose certainties (5) - is staged before a third party (6). A controversy is characterised by the interweaving of various issues, facts and values (7) and by the fact that a definition of the technical and the social is simultaneously at stake (8)". (Seurat and Tari, 2020).

Although controversy is an ongoing process, it is possible to distinguish between its origins and its effects. Upstream of controversies are a number of factors that can make the way in which they end up partly predictable and explicable. These include social and institutional developments, the trajectory of the players involved and the type of resources they mobilised (Lemieux, 2007, p. 192). Downstream, a new reality is taking shape, reflected in new power relationships and new institutional beliefs, in new organisations and new technical devices that are destined to take centre stage (Lemieux, 2007, p. 193). Here, the technical device is an accounting system. It is important to make the distinction between upstream and downstream and to understand that the existence of distinct camps using a set of pre-assigned arguments is the consequence, the effect, and not the cause of the controversy. However, it must be borne in mind that "no result is guaranteed against contestation, but moreover, and this is crucial, what is considered at a given moment to be certain and uncertain varies within the scientific community itself." (Callon, 2006, p. 6)

There is a tension between two poles of analysis (Lemieux, 2007, p. 201). We try not to be drawn exclusively to one or the other. All the following elements are mobilised by the parties in conflict.

The first is the argumentative constraint, which includes "the constraints of coherence, non-contradiction and universality, as well as the procedures for administering rational proof intended to regulate the controversy".

The second is the balance of power, which is understood as "the strategic actions of the various adversaries, [...] their power relationships and their cost-benefit calculations". For example, key characteristics include the position of the organisation to which the individuals belong (international organisation or national office), the position within that organisation (statistician, director or president), recognised expertise, official role in the process and knowledge of the process. Creating alliances can increase their power and promote their ideas.

As far as possible, we will adopt a principle of symmetry (Bloor, 1983, quoted by Lemieux, 2007, p. 210). This means that we will treat (perceived or assumed) 'losers' and 'winners' equally, even if the actual situation is asymmetrical. In this way, everyone's arguments will be set out, and their choices and actions presented as exhaustively and accurately as possible.

In these analyses, critical thinking consists of shifting "the questioning from 'who says what' to 'how and what is said by whom and in relation to whom'" (Seurat and Tari, 2020). We will keep them in mind and try to answer them as soon as our sources allow. More concretely, four main categories of questions are important (Seurat and Tari, 2020).

The first concerns the specialist knowledge involved. What discipline is involved? What are the arguments and issues addressed? Where does the expertise come from?

A second theme concerns the activity of controversy. Where does it come from? What are the intense phases? Are there contrasting positions? How many people are involved, and on what stage? Why is a subject no longer discussed, or why has it been open for decades?

Another category concerns the players themselves. Who are they (by name) and what is their status? What legitimacy do they have? What groups are formed? Which players are mobilised for specific phases?

The last category of questions aims to describe the debate arenas. Who is talking to whom? Who can take part in debates and who is excluded? What circles of influence are mobilised? What types of support and arguments are mobilised? Here, "nothing is more important than the mechanisms by which the identities of participants are determined, the roles they play and the subjects they address. Thus, some actors are silenced, others are confined to an unofficial forum carefully separated from the constitutive forum where the few actors who determine the legitimate issues, arguments and interests are to be found." (Callon, 2006, p. 19)

2.2.Sources

This document is based on an in-depth analysis of the discussions that have taken place at meetings of the London Group (LG), the United Nations Committee of Experts on Environmental and Economic Accounting (UNCEEA) and several related bodies since 1993. This represents a total of fifty-five meetings. Meeting minutes and proceedings are the main sources of information. This is supplemented by a selection of documents and presentations discussed at the meetings. We judge their relevance by their titles. We have reviewed all the documents relating to the assessment of environmental degradation⁷⁹. We have also analysed almost all the documents relating to ecosystem accounting up to 2018, the governance of the SEEA and the collective process leading to the adoption of accounting policies.

Documents discussed after 2009 (with the exception of the 9^e London Group held in 2004) were freely available on the SEEA website⁸⁰. We have gathered most of the documents prior to 2009 in two ways. Firstly by using the Wayback Machine website⁸¹, which archived the formerly public parts of the old SEEA and London Group websites. We also requested minutes and missing documents from the first six meetings of the London Group from Viveka Palm, then Chair (Statistics Sweden), Anton Steurer (Eurostat) and the statistical offices that organised some of the meetings.

To these sources, we have added several academic articles from the scientific literature on environmental accounting. Most of them were written by experts who were or still are involved in the SEEA discussion groups.

As written sources do not provide all the necessary information, we have also interviewed several experts in order to compare our hypotheses and interpretations with the views of people who have experienced the SEEA process. This makes it possible to understand the relationships between the players, to gain a better understanding of their positions during controversies and to identify general trends more easily.

⁷⁹ Although also quantified in monetary terms, the depletion of natural resources is excluded from the field. In fact, this issue has proved to be essentially technical and to have little to do with notions of (ethical or philosophical) values.

⁸⁰ <https://seea.un.org/>

⁸¹ <https://web.archive.org/>

2.3.Methods

In this chapter, we attempt to detail the general history of the process and the controversies. The aim is also to shed light on the balance of power between the players, given by institutional positions inside or outside the process, reputation and other aspects.

In order to understand the place of the monetary valuation controversy, we give an overview of the topics discussed at the meetings, the content of the research agendas and their progress, and the evolution of the structure and content of the manual in preparation. The London Group's and the UNCEEA's objectives, which can be seen in the dedicated strategic documents, are outlined, especially where they have changed. We have also analysed the evolution of governance around the SEEA, focusing on the relationships between expert groups, the rules for joining them and obtaining official positions (chairs, leaders of research agendas, main contributors).

The presentation of the main experts (at least six participations) was facilitated by a correspondence analysis (CA) and a hierarchical ascending classification (HAC) based on the compilation of the lists of participants (for a total of 1,616 participations over the fifty-five meetings). Two CAs were produced: one on all the data and the second on a subset excluding the first seven London Groups (we will see later why it was relevant to use 2003 as the cut-off date). A HAC makes it possible to define five groups of experts in the new spaces defined by the first CA. For the sake of clarity, we have merged the three post-2003 groups, even though they were more distinct from each other than the two pre-2003 sub-groups that we have retained. We made this choice because the second CA is devoted to the second period. For the post-2003 HAC, the HAC groups were not easy to interpret. We therefore manually reconstituted groups on the basis of the number of participants in the meetings (about half the experts in the second HAC were reclassified).

We structure our results by periods delimited by the publications (ES of 1993, 2003, 2012 and 2021). The controversies surrounding many issues did not end with these publications, as the discussions are ongoing. However, these limits constitute milestones where a form of consensus (sometimes incomplete) crystallises. This allows the process to continue on a relatively solid basis. Sub-periods are provided for ease of reading.

With regard to argumentative constraints, we began by proposing a definition of the poles of the sub-controversies identified, based on the explicit definitions of the concept, where they existed. An in-depth reading enabled us to link them to related concepts and ideas and to outline the evolution of the terms. Arguments for and against are given throughout.

3. Description of the framework: players and institutional changes

3.1. Before the SEEA

Norgaard (1989) notes that the seminal ideas concerning environmental accounting date back to the 1970s. After the Rio conference in 1972, economists began proposing changes to the System of national accounts (SNA) "to correct the contradictions" embedded in the economic system concerning the "environment" on which it depended (Nordhaus and Tobin, 1972; Peskin, 1981, 1976).

Six workshops organised jointly by the United Nations Environmental Programme (UNEP) and the World Bank between 1983 and 1988 formed the roots of the SEEA (Ahmad, El Serafy, and Lutz, 1989 bring together the main contributions). These were the first proposals for "environmental economic accounts in the modern sense of the term". (Weber, 2018).

The proposals were made by economists of different persuasions. In addition to Ahmad, El Serafy and Lutz, the contributors were Herman Daly, Anne Harrison, Derek Blades, Rufie Hueting, Jacques Theys, Richard Norgaard, Henry Peskin and Peter Bartelmus. Their initial problem was to rework the definition of GDP to bring it closer to ('real') income as defined by Hicks: sustainable income is the maximum amount that can be consumed without reducing possible consumption in a future period. Two approaches were discussed. The first consisted of removing so-called defensive spending from GDP, i.e. spending to compensate for environmental degradation. The second was to include as capital consumption the depletion of natural resources (Daly, Serafy, Harrison, Peskin) and possibly environmental degradation, if it can be monetised (Hueting). The question of abatement costs is quite prominent in the discussions (Blake), as is that of physical measures (Bartelmus), which appears to be an almost inescapable prerequisite. The question of capital services (one of the roots of future Ecosystem services) was mentioned by Peskin, but not taken up again or explored in depth.

This work was used to carry out experiments in various countries (Mexico, Papua New Guinea, the United States, where a major programme was launched) and questionnaires in various industrialised countries (Lutz, 1993). (Lutz, 1993). On the research side (so to speak, since many experts are involved in all this work), a special conference of the *International Review on Income and Wealth* was held in 1991 to produce a state of the art report on the subject (Franz and Stahmer, 1993). All this fed into the first SEEA, then called IEEA for *Integrated Environmental and Economic Accounting*, published in 1993.

In 1994, the London Group, named after the location of their first meeting, was set up by the UK *Office for National Statistics*, Statistics Canada and Eurostat (UNSC/35/LG/8; Alfieri, pers. comm., 07/05/2021). This follows on from the IEEA 1993 publication and responds to the feeling that national accountants should be more involved in the drafting of such a manual in the future. Indeed, this publication was seen as a 'coup d'état' by the UN (Bartelmus, 2014). The IEEA 1993 is based on work carried out by economists (Ahmad et al., 1989) during the 1980s, but the manual itself is the result of a year's work by Peter Bartelmus, Jan von Tongeren (United Nations Statistical Office) and Carsten Stahmer (German Federal Statistical Office). Revisions to the System of national accounts (economic) are usually the result of "a long process of agreement, commitment and compromise, to get everyone on board" (Radermacher, pers. comm. 27/07/2020). In this case, however, only three authors wrote the manual. In addition, although the subtitle indicates that it is a "provisional version", it is labelled "National accounting manual", which is more binding.

3.2. Actors and institutions involved in the SEEA from 1993 to 2021

Two formal groups have built the SEEA: the London Group, created in 1994 (we will use the acronyms LG) and the United Nations Committee of Experts on Environmental and Economic Accounting, created in 2006 (UNCEEA). The secretariat of the London Group was initially provided by the Statistical Office of Canada, before being replaced by the United Nations Statistics Division (UNSD), which is made up of UN officials. The composition of these groups has changed over time, and many personalities and organisations have taken part. So, because we will be quoting these players regularly, it is necessary to give an overview of their presence over time.

Figure 25 shows the number of participants in each group over time. This number has been evolving slowly, but the average has risen from around thirty people to fifty today. The UNCEEA was aiming for twenty-five "permanent" members, but we can see that occasional guests always added to the size of the group. The last three meetings were held by videoconference, which explains the very high number of participants in the 26^e LG.

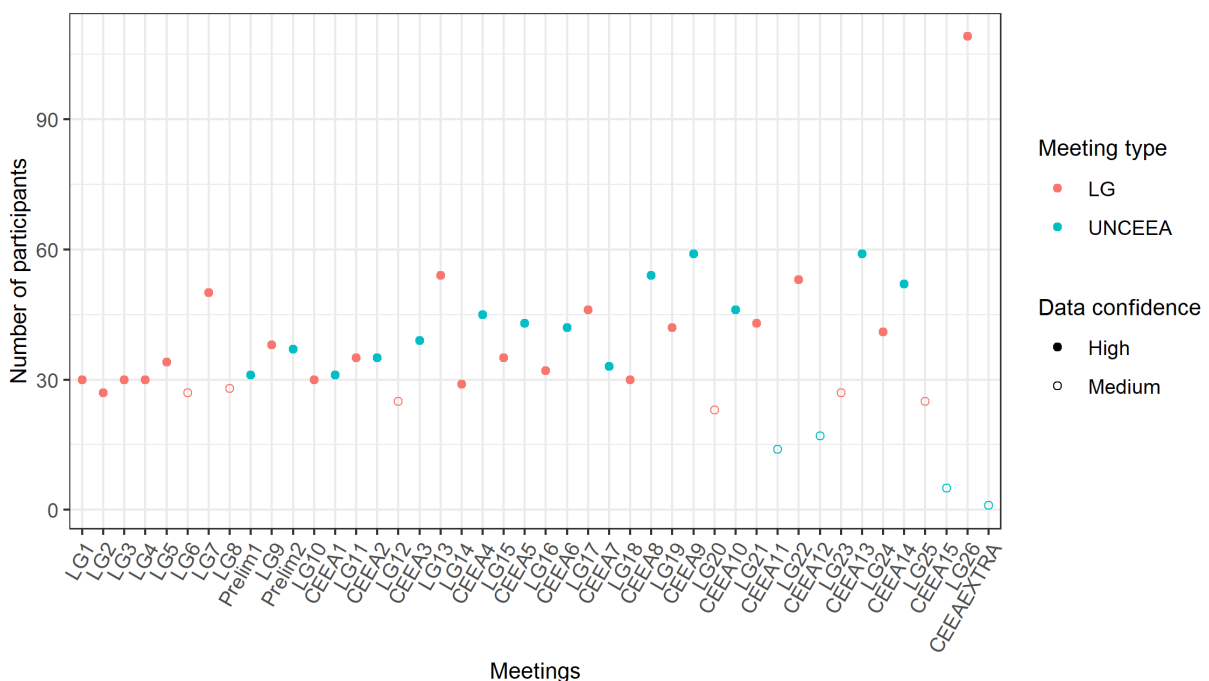


Figure 25 Number of participants in SEEA meetings

Legend: the data generally comes from official lists of participants (high confidence). Where these were not available, we have used the names mentioned in agendas (provisional or otherwise), presentations and minutes (medium confidence, as all these data underestimate the actual number).

We have listed sixty-seven people who have participated in at least six meetings of the London Group or the UNCEEA. On the basis of their participation, we can draw groups of experts who have played a significant role in the economic and environmental accounts developed for the SEEA. In the text that follows, the experts in bold have played a particular role in our story (chairmen, leaders of research agendas, key players, etc.). Figure 26 and Figure 27 show the results of the quantitative analyses.

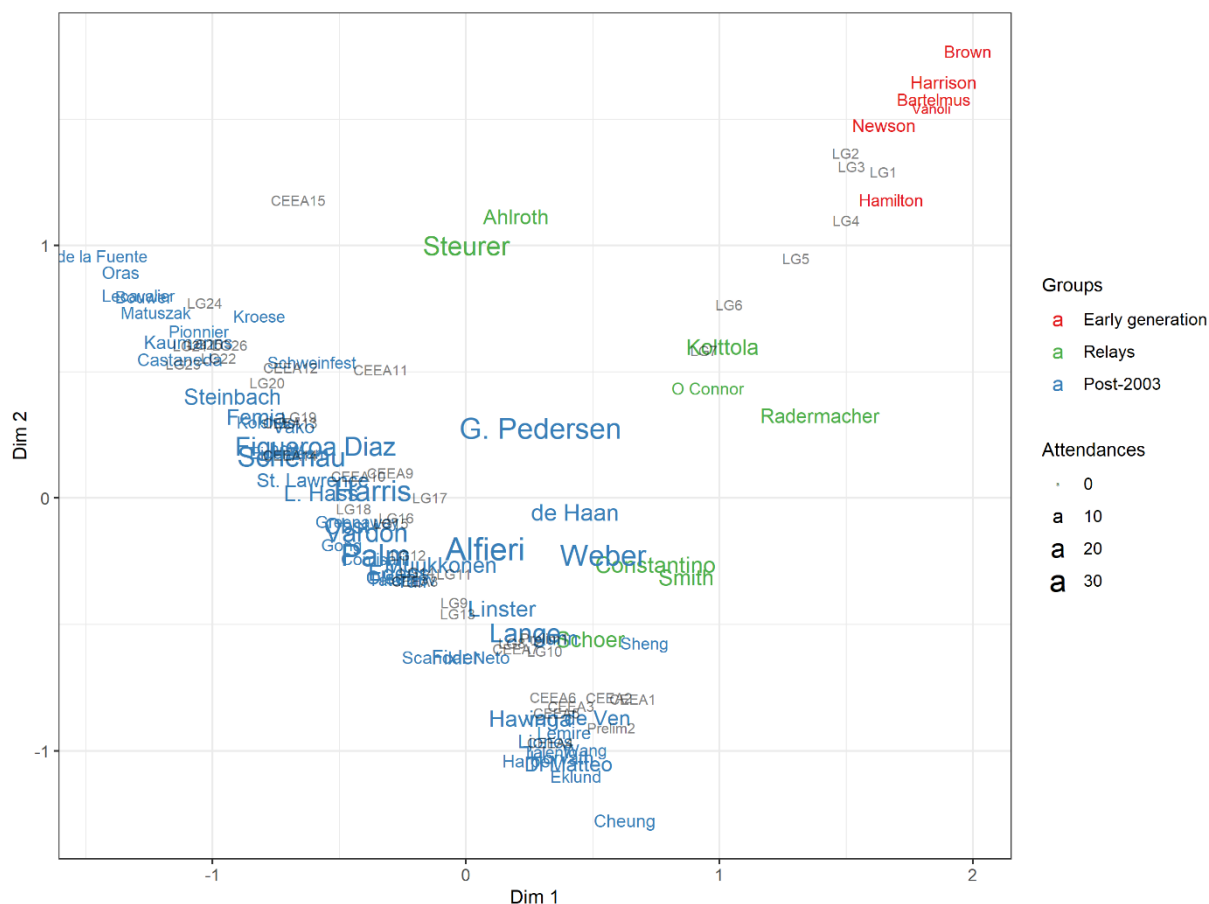


Figure 26 SEEA expert groups over the period 1994-2021

Figure 26 shows a first group (in red) that is far removed from the graph. It includes **Peter Bartelmus** (UNSD, author of the SEEA 1993), Anne Harrison (OECD, she was the editor of the SEEA 2003), **Kirk Hamilton** (World Bank), Brian Newson (Eurostat), Alan Brown (UK Department of the Environment) and **André Vanoli**. This first group is the first generation of National accounting, which stopped with or before the publication of the SEEA 2003. Similarly, the remote position of the first 6 LGs (this is slightly less the case for LG7) indicates that there are very few people in common with the post-2003 period. The first generation included "the thinkers, the theorists of National accounting". National accounting today is a much smaller community. In the SEEA, only "Ole Gravgard Pedersen and **Peter NPV** have remained" (Alfieri, pers. comm., 07/05/2021).

We call the second group the "relays" because they are a sort of bridge between the first seven LG meetings and the post-2003 period. They took part in around 12 meetings, before and after 2003. The automatic classification includes **Walter Radermacher** (Germany, then Eurostat) and **Martin O'Connor** (France) in this group. Based on the raw data, we have manually added Robert Smith (Canada, first chairman of the LG), **Karl Shoer** (Germany, he co-published with Radermacher), and Cesare Constantino (Italy). They all attended at least three of the first seven meetings of the London Group, but only stayed until 2006-2008. Automatic classification also created this group by including **Anton Steurer** (Eurostat), Leo Koltola (Finland) and Sofia Ahlroth (Sweden, then the World Bank), who attended most of the first LG meetings and returned after a break of more than ten years. Steurer and Ahlroth were instrumental in the revision of the SEEA EA 2020.

The post-2003 period, shown in blue, is much more continuous, yet distinct from the first phase. The renewal of experts was more regular. The group thus extends from the earlier periods (bottom right) to the current period (top left). Figure 27 details the period after 2003.

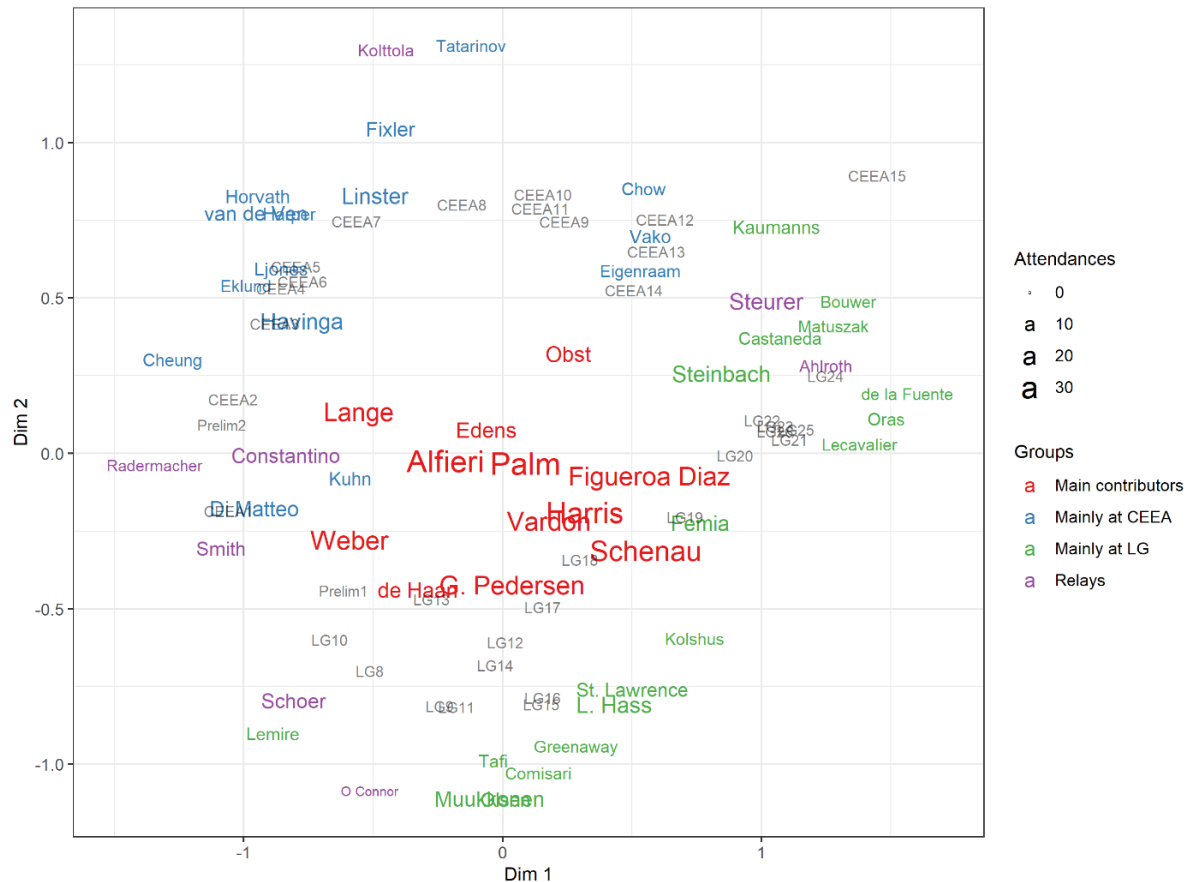


Figure 27 Groups of 'experts of the SEEA after 2003

Legend: Figure based on a subset of post-2003 data to detail the 'Post-2003' group in Figure 26.

A third group of experts appears. It brings together the main contributors to the SEEA (in red). On average, they have taken part in 24 meetings and at least two revisions of the SEEA. **Alessandra Alfieri** (UNSD) and Ole Gravgard Pedersen (Denmark) saw the start of the SEEA and were still present in 2020. **Jean-Louis Weber** (France, then European Environmental Agency) began working on environmental accounting in the 1980s, and stopped attending SEEA meetings after the publication of SEEA 2012. Others came a little later, such as **Mark de Haan** (Netherlands, he started at LG4), **Glenn-Marie Lange** (World Bank, she replaced Hamilton), Rocky Harris (UK Department for Environment, Food and Rural Affairs), Viveka Palm (Sweden), Sjoerd Schenau (Netherlands), Raul Figueora Diaz (Mexico) and **Micheal Vardon** (Australia, he worked several years for UNSD and the World Bank). We have manually added **Carl Obst** (Australia, editor of SEEA 2012 and 2020) and Bram Edens (UNSD) to this group. Although they only attended twelve meetings, they have significantly shaped the SEEA.

We noticed that after the creation of the UNCEEA, some people attended almost exclusively UNCEEA or London Group meetings. This is linked to the rules of admission (more or less formal) to the UNCEEA. We have therefore reclassified the experts. This defines two new groups.

Key LG participants include Joe St Lawrence (Canada, and Chair of the London Group between 2012 and 2016), **Aldo Femia** (Italy), Nancy Steinbach (Sweden) and Sven Kaumanns (Germany, current LG Chair). On average, they attended ten LGs after 2000, but none or few UNCEEA meetings.

The main participants in the UNCEEA (more than ten UNCEEA meetings) are Peter NPV (Netherlands, then OECD), Dennis Fixler (Bureau of Economic Analysis, USA), Myriam Linster (OECD), and Ivo Havinga (UNSD). The group also includes Bert Kroese (Netherlands), current chairman of the UNCEEA.

Although he did not attend any SEEA meetings, one last name worth mentioning is that of **Rufie Hueting**. The strong personality and influence of this Dutch economist had a considerable impact on the SEEA in the 1990s.

Figure 28 shows that the UN Statistical Division was the most present at the meetings (which seems natural, as the secretariat), followed by the Netherlands, Sweden and Canada. We shall see that the Netherlands, Australia, the Scandinavian countries, Germany and Eurostat made a particularly significant contribution.

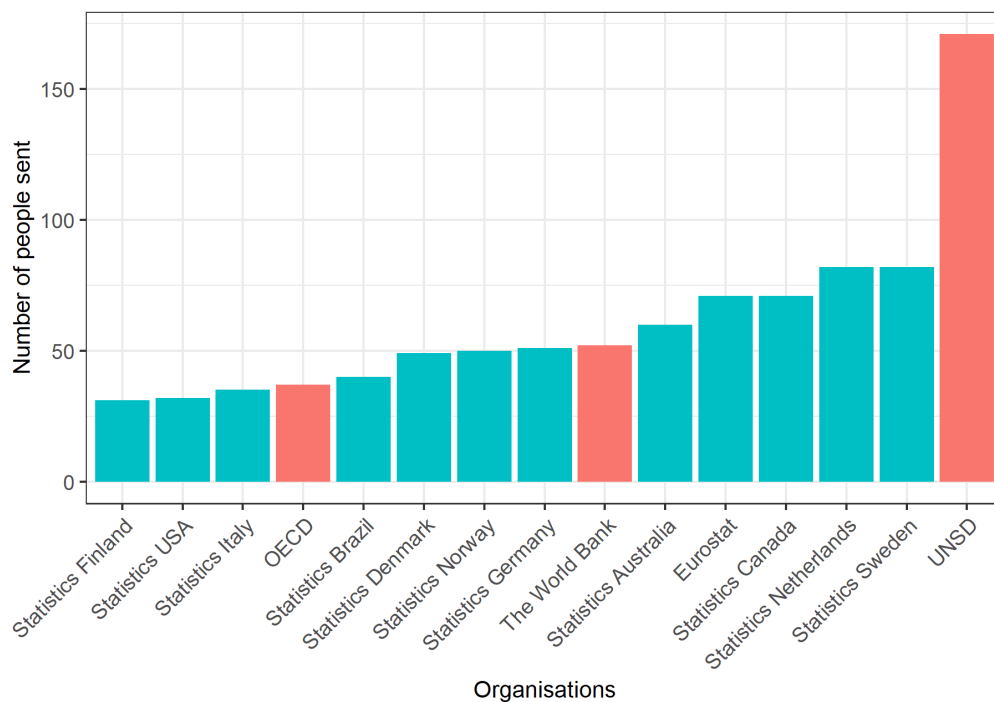


Figure 28 Breakdown of organisations present

It should be noted that the United States is in a special situation: its representatives were not officially sent to SEEA meetings, because the US Congress passed a law in the mid-1990s banning environmental accounting. As a result, their role was much smaller than in other international processes.

3.3.Key periods, changes in governance and research themes

The main players in this process have interacted in a particular context, which includes specific governance that has changed over the last three decades. In addition, the issues addressed have not been the same over time, in particular because some have matured more quickly than others.

3.3.1.A collegial group working on abiotic issues and monetary accounts - and a difficult revision (1993 to 2003)

This period is delimited by the publications of the provisional version of Integrated Environmental and Economic Accounting in 1993 (United Nations, 1993a) and the 2003 version (United Nations et al., 2003). We divide the period into two parts.

3.3.1.1. *Gather and build knowledge (LG 1, 2, 3, 4)*

The LG was set up as a discussion forum for experts wishing to share their experience of environmental accounting (LG/9/pro, p.9). At the time, the group was mainly made up of National accounting experts. A few economists participated as representatives of international organisations (Bartelmus, von Tongeren, Harrison or Hamilton) or as researchers (in 1996 and later: O'Connor). As most of the economists involved in the 1980s did not join the LG, the few remaining economists were far fewer in number than the national accountants.

People attended the meetings on a voluntary basis and at the expense of their organisation. This limited the number of participants and, in particular, de facto excluded low-income countries. Financial support from the UNSD after 1997 made it possible for countries wishing to attend to do so.

The first group in London consisted of presentations of documents describing the national environmental accounts in the participants' countries. The aim was twofold: "to identify best practice and areas for further work and development" (LG/1/pro, p.3). There were three main groups of countries:

- countries that have only just begun to work on environmental accounting (e.g. Australia and the United Kingdom),
- those who have built such accounts over the last three years, with trends close to the 1993 EEI (notably Canada, Japan, Finland, Sweden and Denmark),
- those with five to ten years' experience (France, Germany and Norway). The latter group had built accounting systems that were sometimes very different from the IEEA 1993.

With regard to the subject of interest in these accounts, it is stated that:

"To a large extent, areas of environmental accounting focused on individual countries reflect the particular nature of environmental health or problems within their borders. Countries with vast forest, wildlife or subsoil mineral resources, such as Australia, Canada, Finland and the United States, have focused on measuring the size of the stock and the rate of depletion of their natural resource wealth. Central European countries, whose commercial resource bases are smaller in relation to their national economies and whose population densities are higher, have focused more on measuring the harmful and polluting impact of human activity on the natural environment" (LG/1/pro, p.1).

Discussions on the different accounting frameworks and aggregate adjustments followed. As representatives of the United Nations and principal authors of the IEEA 2003, Bartelmus and von Tongeren made a "very substantial contribution" to the meeting (LG/1/pro, p.1). Eurostat's main contribution concerns "expenditure on pollution control and emission reduction". Their classification of this expenditure, SERIEE, "has arguably been the de facto world standard" (LG/1/pro, p.2).

The second meeting of the London Group in Washington (1995) was devoted entirely to the question of monetary valuation. We will come back to this in detail in the section describing the history of this controversy.

The third meeting, which took place in Stockholm in 1996 (LG3), demonstrated the progress made by countries and examined three subjects in greater depth: forestry accounts, material flows and the cost of pollution. The experts chose to finalise the areas that were well advanced, to develop little-explored areas such as water accounts, to work on environmental protection expenditure accounts and to experiment with the measurement of environmental damage and its monetary valuation.

During the meeting, the group reviewed its organisation. It felt that it was the right size, "small enough to be effective, but large enough to encompass a wide range of experience" (LG/3/pro, p.423). However, it was too early to create a standard similar to the System of national accounts, despite the progress made by countries. Environmental accounting was still evolving too much and "priority should be given to collecting the core data sets needed to compile and test environmental accounts rather than spending too much time refining frameworks" (LG/3/pro, p.423).

In order to better organise the discussions, the London group set three objectives for the fourth meeting in Ottawa (LG4): to reach consensus where possible; to declare that no consensus could be reached for the time being; and, where appropriate, to draw conclusions. Statistics Canada offered to take on the role of LG secretariat (UNSC/35/LG/8). Eight internet discussion groups were formed to continue and prepare for future discussions.

Bartelmus, Harrison and de Haan presented papers for the first session on a possible revision of the SEEA, proposed by the United Nations Statistical Commission (UNSC), and how the LG could be involved. A review could help countries to disentangle the many approaches proposed and the controversies surrounding them. It aims to address the main criticism of the 1993 SEEA, namely the difficulty of implementation. The process would lead to an update without being a formal revision like those of the System of national accounts (LG/4/pro, p.63).

At its 29^{ème} session (March 1998), the UNSC endorsed the UNSD's suggestion to "collaborate with the London Group on the revision of the System of Integrated Environmental and Economic Accounting (SEEA)" (UNSC/29/LG), although some members expressed concern at the limited technical improvements made to date.

3.3.1.2. A difficult revision (LG 5, 6, 7)

The launch of the revision of the SEEA was the main topic of discussion at the Fontevraud meeting (May 1998). Members volunteered to contribute to thematic "groups" (overall description of the system, asset accounts, environmental expenditure accounts, monetary valuation, and applications). Each group was asked to appoint an editor/coordinator during the meeting or in the following months (the names are available in the LG6 proceedings and in Table 14 below⁸²). The UNSD took responsibility for preparing the final draft and facilitating discussion with other UN groups and commissions. A coordinating committee comprising the UNSD, Eurostat and Statistics Canada was set up to coordinate work on all the chapters. The members agreed to draw up a draft for the next meeting in Canberra in 1999, on the basis of what was agreed in Fontevraud (LG/5/pro, pp.45-46).

⁸² Between 6^e and 7^e LG, some chapters were subdivided. Our sources do not mention the actual contributors after 6^e LG. The experts who presented the chapters during the 7^e LG are mentioned. They are certainly the coordinators or at least the contributors most familiar with the subject.

Table 14 Contributors to the SEEA 2003

	Name	Organisation	1- Framework		2- Assets		3- Physical flows		4- EP&RM	5- Valuation	6- Applications
LG6	A. Harrison	OECD									Coordinator
	M. de Haan	Stat. Netherlands					Coordinator				
	A. Brown	UK Dep. of the Env.						Coordinator			
	A. Steurer	Eurostat						x	Coordinator		
	R. Harris	DEFRA	Coordinator								
	A. Alfieri	UNSD	x		Coordinator						
	B. Fraumeni	Stat. USA	x								
	M. Ward	The World Bank	x								
	B. Harrison	Stat. Australia	x				x	x	x		x
	R. Smith	Stat. Canada	x		x		x	x			
	E. Domingo	Stat. Philippines			x						x
	J.-L. Weber	Stat. France			x						x
	S. Thompson	Stat. Australia			x						
	L. Koltola	Stat. Finland			x						
	K. Sorensen	Stat. Norway			x						
	O. G. Pedersen	Stat. Denmark					x				
	K. Schoer	Stat. Germany					x				
	B. Thomas	?					x				
	P. Bartelmus	UNSD					x			x	
	K. Hamilton	The World Bank								x	
	S. Ahlroth	The World Bank								?	
	A. Wadeskog	Stat. Sweden									x
	J. Hecht	Consultant									?
	G.-M. Lange	The Earth Institute									?
LG7	Name	Organisation	1- Introduction	2- Structure	6- Assets	7- Specific resources	3- Physical flows	4- Integrated physical and monetary	5- EP&RM	8- Valuing degradation	9- Applications and uses
	A. Harrison	OECD									Editor
	R. Harris	DEFRA	Presenter	Presenter							
	B. Harrison	Stat. Australia			Presenter						
	A. Alfieri	UNSD				Presenter					
	O. G. Pedersen	Stat. Denmark					Presenter				
	M. de Haan	Stat. Netherlands						Presenter			
	A. Steurer	Eurostat							Presenter		
	S. Ahlroth	The World Bank								Presenter	
	G.-M. Lange	The Earth Institute									Presenter

Legend: EP&RM stands for environmental production and resources management.

A major consultation was organised to gather feedback from statistical offices, but also from economists, NGOs and "appropriate representatives of developing countries" (LG/6/minutes). By the sixth LG, "the main objective of SEEA-2000⁸³ was to be an internationally accepted best practice document", not a statistical standard. This decision was taken because it was already clear that consensus would be difficult and that not enough progress had been made compared with the SEEA 1993.

The years 1999 to 2002 were entirely devoted to drafting the new SEEA. The revision was rather complicated for several reasons. The first was strictly material. The 6^e and 7^e LG meetings provided an opportunity to discuss the draft chapters together, while progress was made in groups between these meetings. The LG website was used as a medium for discussion (a novelty at the time), while emails were exchanged if necessary. However, this system was not sufficient to ensure that the discussions flowed smoothly (UNSC/31/LG/6).

⁸³ The work was eventually delayed, leading to publication in 2003, and the renaming of the manual as "SEEA 2003". Incidentally, the term integrated accounting (giving rise to the acronym IEEA) or system of accounts (SEEA) is the subject of much debate.

Then, the other professional commitments of the main contributors and the lack of dedicated funding to work on the revision slowed down the drafting process. At the suggestion of Statistics Canada, and with the agreement of the LG, Anne Harrison was finally hired as editor-in-chief of the SEEA-2000 during 1999 to better coordinate the work. This post was funded by most of the organisations involved (UNSC/31/LG/6). After the summer of 2000, the chapters had been structured, but were not sufficiently complete to be discussed in plenary.

In particular, reaching a consensus on the monetary valuation of the degradation proved impossible. We'll come back to this later. The strong personalities and sometimes opposing schools of thought led to very lively exchanges.

As a result, the Voorburg meeting was moved from October 2000 to May 2001 (UNSC/32/LG). This meeting was particularly productive (UNSC/33/LG/7/short). Although it was not always possible to reach agreement, it at least made it possible to clearly set out the alternatives envisaged.

The SEEA was finally completed in January 2002 (UNSC/33/LG/7/short). But it was not until two years later, in March 2004, that the UNSC "noted that the System of national accounts manual on integrated environmental and economic accounting, 2003 (SEEA-2003) had been published on the United Nations Statistics Division website and as a '*white cover publication*'" (UNSC/35/LG/8). This document was never officially published by the intended authors (OECD, Eurostat, World Bank, UN).

"The SEEA 2003 was not officially published because there was no, shall we say, ownership on the part of the international agencies. It was mainly driven by the national statistical offices. The process was imperfect because there was no formal international process". (Alfieri, pers. comm., 07/05/2021)

Still, it was an important step. The manual summarises the experience gained over the previous nine years. In this respect, the SEEA 2003 has achieved the objective set by the countries that felt excluded from drafting it in 1993. It describes "a very wide variety of methods. It is quite illustrative of what we could do" (de Haan, pers. comm., 19/05/2021). A large section is devoted to physical accounts, which is an innovation compared with the 1993 SEEA. In addition, it proposes alternatives for constructing accounts when no consensus has been reached. However, some experts believe that the document missed the point because there was no well-structured set of accounts (O'Connor, pers. comm., 04/11/2020; Bartelmus, 2006).

3.3.2. Consolidate the existing SNA-type governance (2004 to 2013)

This period is devoted to the creation of an international statistical standard, and no longer to bringing together methods and feedback in a manual. Originally intended to be called SEEA 2010, the "central framework" was finally published in 2012, and the "experimental ecosystem accounts" in 2013.

In 2004, a new governance structure was rapidly put in place. As a result, the number of annual meetings doubled, not to mention the sub-groups set up from 2010 onwards. We will therefore leave aside a linear narrative to focus on key aspects. From its creation in 2006, the major decisions surrounding the SEEA were taken by the UNCEE. We will therefore largely leave the LG out of this section on governance. It will be discussed again in the following sections, which describe in detail the controversies surrounding monetary valuation.

We have divided this period into three phases: a new work organisation (September 2004 to June 2006), the construction of an accounting standard (June 2006 to December 2009) and the final acceleration (2010 to June 2013) to complete the work.

3.3.2.1. A new organisation (mid-2004 to June 2006)

This period was characterised by the creation of the UNCEEA and its links with the London Group. The improvement of water accounts (a more advanced and consensual subject) is another notable aspect, but we will not dwell on it here.

The governance around the SEEA began to change after the publication of the 2003 version. The UN organised two preliminary meetings in 2004 and 2005 to create the United Nations Committee of Experts on Environmental and Economic Accounting (UNCEEA). Several high-quality documents are worth mentioning: on the implementation and promotion of environmental accounts, the link with indicators and other producers, and preliminary research agendas.

Initially conceived as a working group, it eventually became a committee linked to the UN. Indeed, "the participants felt that it was appropriate for environmental and economic accounting to be hosted by an international organisation. They recognised that the United Nations was the most appropriate organisation to take on this role and welcomed the UNSD/UNEP proposal" (LG/9/minutes). This was to enable the UNSD/UNEP to acquire official international status and to be able to support the creation of an international standard. A mere group of experts, most of whom did not hold senior positions in their respective organisations, could not do this.

The main architects of this governance are certainly Alessandra Alfieri (UNSD) and Walter Radermacher (first president of the UNCEEA). They drew inspiration from other similar processes (System of national accounts, balance of payments, etc.), but also innovated. In comparison, for example, with the governance of the balance of payments (where countries contribute their expertise and make proposals, but where the IMF takes the final decisions), they have chosen to give countries a much more important role. According to Alfieri (pers. comm., 07/05/2021), Radermacher felt strongly about this aspect. For example, a member country chairs the UNCEEA, while the LG looks after the technical aspects and helps to draw up the research agenda.

The members agreed on three main objectives for this new entity: "to give the SEEA a central place"; "to raise the SEEA to the level of an international standard"; "to advance implementation in the countries" (LG/9/minutes). This was an opportunity to define the various areas of the terms of reference⁸⁴ (see Box 4 for a summary of the discussions).

The members decided that the composition of the committee should remain below 25 countries and international organisations in order to ensure in-depth discussions. High-level representatives should be favoured to exercise its strategic role. The committee will report annually to the UNSC on the progress of the work undertaken.

This committee was set up to improve the work of the London group, which had gaps that were filled in the UNCEEA terms of reference (LG/9/minutes). Hecht (2005) also points to the need to widen the audience beyond national accountants in order to produce useful and used accounts. In fact, the LG had been moving in this direction, but very shortly before: it set up a sub-group on uses in public policy

⁸⁴ They have not changed since the first UNCEEA meeting.

at the 8^e LG in Rome (November 2003). At the next meeting, it was formally agreed that public policy uses should be discussed at every meeting.

Box 4: Summary of discussions on the UNCEEA terms of reference

Coordination: although there is good coordination between members, there is no coordination between international agencies. The UNCEEA could maintain a website as a knowledge platform, send out a newsletter, and carry out a global assessment of the implementation of economic and environmental accounting, its uses and needs. The second preliminary meeting added a coordinating role for all UN city groups involved in environmental and economic accounting.

Promotion and implementation of accounts: economic and environmental accounting was mainly supply-driven, but potential users were unaware of its potential. It was proposed that UNCEEA publish articles on potential policy uses and organise meetings. During the meeting, they approved the organisation of dialogues between users and producers.

Methodology: despite the significant work carried out to date, raising the SEEA to an international standard is not yet within reach. The UNCEEA will propose an agenda in coordination with the London Group. To this end, the minutes indicate that the UNSD should extend the consultation to a wider range of users and producers in order to produce a list of questions by mid-2006.

Technical cooperation: the current versions of the SEEA were considered too theoretical to be easily used by countries and statisticians newly involved. The UNCEEA would publish guidelines in several languages and the UN regional commissions could play a role in creating regional approaches.

Harmonisation of data: although many statistics are produced, they are produced by different agencies and are not always suitable for accounting purposes. There was a consensus that the UNCEEA should work on this issue. For example, it was proposed that guidelines should be drawn up on how data should be collected and that international data sources should be explored.

It was decided that the LG should continue to exist to provide "a body of expertise on which [the UNCEEA] can draw for the development of methodologies and guidelines and for the review of documents prepared by the Committee's subgroups" (LG/9/minutes). In this way, it receives most of the research agenda drawn up by the UNCEEA with a view to resolving the methodological issues that need to be taken forward. We shall see later that, at this point, the LG preferred to entrust the question of monetary valuation, which was still too controversial, to the UNCEEA.

The LG's new governance structure was ratified at the 10^e LG. A chairman will be elected by the members and the UNSD will act as secretariat. The members of the group requested that: "The chairman, when formulating the management structure of the project, should seek a broad consensus with the members of the group, bearing in mind the previous management style of the group" (LG/10/minutes). Mark de Haan became Chairman of the LG at this point.

Although viewed positively by many, these organisational changes did alter the balance of power, as some members were quick to point out. Right from the start of the revision, the UNSD gained in influence, thanks to its role as secretariat to the UNCEEA and the LG. Its presence on all the SEEA bodies and its knowledge of international decision-making mechanisms gave it an overall view of the situation,

which gave it an advantage over the more ad hoc players. Generally speaking, this led to good coordination between the groups and greater efficiency in the discussions.

As far as governance was concerned, the effects were also felt: the chairs of the groups and the proposals for reorganising governance that followed were often proposed by the UNSD. Although the group chairmanships are prestigious, there are rarely many candidates, as it is also a lot of work (Peter Harper, pers. comm., 17/05/2021). The rest of the UNCEEA board also had an upstream role. And downstream, the decisions have to be accepted more or less formally by the members. This did not stop some experts from criticising the choices made.

Secondary positions such as research agenda leaders are chosen in a somewhat similar way, with, it seems, a greater proportion of volunteers. In this type of international process, these roles require the ability to move work forward and the capacity to generate consensus. Expertise on the subject is also important, as is similar international experience (Obst, pers. comm., 10/05/2021; to be verified).

At the first meeting of the UNCEEA in 2006, the strategy and research agendas were discussed. Walter Radermacher was elected chairman. The UNCEEA agreed that the SEEA accounts that have the highest level of quality, measurability and consistency should form part of the official statistics. Finally, the Committee decided to engage an editor who should be "(b) able to reach consensus, (c) impartial and (d) a native English speaker" (UNCEEA/1/minutes).

3.3.2.2. First phase of the review (mid-2006 to end-2009)

At the UNCEEA2, it was agreed how the UNCEEA would relate to other international committees and groups. In particular, the UNCEEA will report to the UNSC on its progress, as the LG used to do. The issue of funding was addressed. It is estimated that 1.25 million US dollars will be needed to complete the review (salary of the editor, consultants, organisation of meetings and assistance to countries in difficulty). These funds will come from international organisations and member countries (UNCEEA/2/5).

In addition to progress on the various technical aspects, one point discussed at the LG is particularly noteworthy. At the 12^e meeting in 2007, the LG Chairman proposed a structure for the various volumes of the SEEA (LG/11/3a) (see also the "Technical aspects" section). Box 7 of this chapter, page 179). The first volume is intended to become the statistical standard, while a second will contain the more controversial aspects (monetary valuation of degradation) and the less advanced aspects (ecosystem accounts). A third volume would describe the possible uses of the accounts from a 'user' perspective, i.e. less concerned with accounting techniques. This last volume echoes the German proposals made at the first meetings of the UNCEEA: to discuss sustainability, while maintaining the neutrality of the statistical framework. Finally, it shows the advantages of using the SEEA and is an important aspect of the strategy to promote the SEEA.

In this section, we will very briefly mention the substantive advances made in the first volume, which will become the central framework for the SEEA 2012. Its content is of less interest to us for this chapter, which is why we leave it in this general section. Volume 2, which will become the experimental ecosystem accounts of the SEEA, will be at the heart of the monetary valuation controversy, which we will discuss later.

At the UNCEEAA3 (2008), the governance of this committee was presented for discussion, but was not stabilised until the following year (Figure 29). It was also decided that "an advisory group will be drawn from the London Group on Environmental Accounting and will play an essential role in the process of revising and updating the [SEEA]" (UNCEEAA/3/5). This will be the future editorial board. The UNCEEAA can therefore submit requests to the LG and select some of its members to participate more actively in the revision, but the LG cannot take final decisions on content.

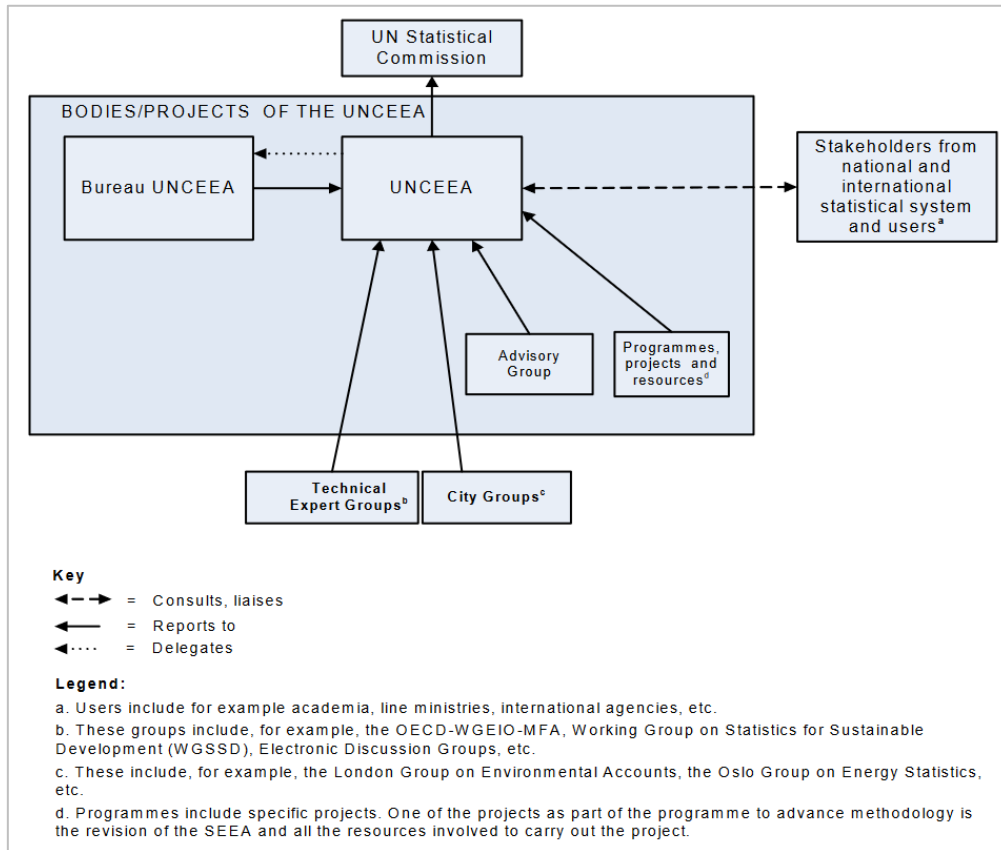


Figure 29: Governance of the 2003 SEEA review (source: UNCEEAA/4/5)

Walter Radermacher completed his term of office as Chairman at this meeting. He was replaced by Peter Harper (Economic Statistician, Australian Bureau of Statistics). As Radermacher had become Director General of Eurostat, he did not return to the SEEA meetings. He was replaced by Micheal Kuhn (Head of the Economic and Environmental Accounts Division at the German Statistical Office).

Since February 2008, the UNCEEAA Bureau is composed of Peter Harper, Rashad Cassim (Deputy Director General, Statistics South Africa), Estrella Domingo (Deputy Secretary General, National Statistics Coordination Board, Philippines), Pieter Everaers (Director of Agriculture and Environment Statistics, Eurostat), Peter NPV (Head of National Accounts, Statistics Netherlands), Karen Wilson (Deputy Chief Statistician, Statistics Canada) and the UNSD (as UNCEEAA Secretariat) (UNCEEAA/4/5).

The criteria for including an item in the research agenda have also been stabilised. They are reproduced below Box 5.

Box 5: Criteria for adding an item to the research agenda (source: UNCEEA/3/11)

The criteria for including the issues in the research agenda for the revision of the SEEA include the following:

- (a) There should be no fundamental changes to the SEEA, however further development and standardisation of classifications may be warranted (e.g. classifications of physical flows);
- (b) A broad base demand exists by users;
- (c) A significant number of country experiences exist and consensus on its resolution is expected;
- (d) Any recommendation should be assessed for consistency with the 1993 SNA Rev.1 and consistency with other macroeconomic statistical standards such as the Balance of Payments Manual Rev.6, the Government Finance Statistics Manual, International Standard Classification of all Economic Activities Rev.4 and the Central Product Classification version 2, etc. Similar considerations on consistency should also apply to the business accounting standards;
- (e) Any recommendation should take into account the feasibility of implementation and not compromise international comparability.

In addition, for those issues for which no methodological consensus is expected, the following criterion should be added:

- (f) Policy relevance has been demonstrated and country practices are well advanced to warrant further elaboration.

At the 4^e UNCEEA meeting (June 2009), pledges of financial and in-kind contributions for the revision were presented. Out of a total of nearly US\$400,000, Eurostat would contribute \$208,000. The national statistical offices would provide the remainder. Norway and Australia are the biggest contributors, to the tune of \$30,000 (with Australia also providing P. Comisari for 6 months as interim editor), followed by the Netherlands, India, South Africa and the United Kingdom (\$25,000 each). Switzerland and New Zealand are the next largest contributors (\$10,000 and \$12,000 respectively), along with Germany, which did not specify an amount at the time (UNCEEA/4/13).

3.3.2.3. Final acceleration (end 2009-March 2013)

During the 15^e LG, most of the remaining issues from volume 1 and some from volume 2 were addressed. The UNSC stressed the need to finalise the SEEA fairly quickly.

The 5^e UNCEEA meeting (June 2010) provided an opportunity to review the organisation of the revision. The first volume, which is to become a statistical standard (the future central framework), is the subject of separate governance. A close link with the BA must be maintained to enable this volume to be a satellite system. The LG is responsible for resolving the majority of issues on the research agenda and for proposing position papers on these subjects, and then for revising the chapters written by the editor. When Carl Obst was hired in mid-2010 to take on this role, an Editorial Board was set up to assist him. The UNSD does the same, by delegation from the UNCEEA Board. All report to the UNCEEA. The main role of the editorial committee is to take decisions on the basis of the summary documents produced by the LG and to revise the chapters being written. It must seek the greatest possible consensus. If this is not possible, it reports to the UNCEEA, whose board takes the final decisions if necessary (UNCEEA/5/5).

In addition, a sub-group led by the UNSD, the European Environmental Agency and the World Bank has been set up to work on experimental ecosystem accounts (UNCEEA/6/6). Three meetings of experts were held in May and December 2011, and May 2012.

Applications and extensions, the subject of a third volume, are also written by dedicated experts.

The arrival of the editor, Carl Obst, in May 2010, and the implementation of this new organisation has speeded up the drafting process considerably. Significant progress was made at the 6^e UNCEEA

meeting. The "central framework", as volume 1, directed by Mr Obst, is well on the way to publication. A worldwide consultation is being carried out on its six chapters.

The 7^e UNCEEAA meeting in June 2012 no longer discussed the content of the ES FC, which is now ready for publication, but the strategy for its use. Various organisations presented how they intended to mobilise this new standard: the World Bank (through the WAVES project), the OECD, Eurostat (with a directive in preparation), the UN Sustainable Development Division (with the Sustainable Development Goals), the Dutch statistical office, and Russia. The status of the other two volumes still being drafted was discussed in more depth, but there were no minutes to give details of what was said. The creation in April 2012 of the *Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services* (IPBES) was mentioned as further evidence that expectations on ecosystem accounts would be high.

The central framework of the SEEA was finally presented to the UNSC for adoption in March 2012 (at the 43^e session). Without going into detail, it should be noted that the adoption of a statistical standard is the subject of intense negotiations, most of which take place at the last minute, despite all the work done upstream. Member countries can in fact exercise a certain veto. Alfieri (pers. comm., 07/05/2021) recounts that:

"The issue of monetary valuation of resource depletion was at the heart of the debate. Some countries expressed reservations, believing that the methodology was not sufficiently advanced. What's more, some pure National accounting experts (the United States, for example) were against calling the physical part "accounts". The discussion was a struggle for the FC. The session had to be interrupted, and we had informal negotiations in the corridor. The final wording was therefore "initial statistical standard". When the report was discussed, we had another 3 hours of discussions about 'first' or 'initial' or nothing."

Experimental ecosystem accounts and applications and extensions follow the same process, but as they are not standards, they are not discussed as much at the UNSC. The SEEA EEA was accepted in March 2013.

3.3.3. Enlargement of the community to work on ecosystems and stratification of governance

From then on, most of the fundamental work was focused on experimental accounts of ecosystems. A new underlying trend during this third period was the opening up of the community to academic research (Obst, 2015). Ecological issues go beyond the remit of the statisticians and National accountants involved.

The rest of the work of the UNCEEAA and the LG is to promote the central framework and adapt it on the basis of feedback from the countries that apply it. More specific technical recommendations are also drawn up.

3.3.3.1. Experiments with the SEEA EEA and reorganisation of governance (June 2013 to mid-2016)

At its 8^e meeting, the UNCEEAA discussed its organisation and work plans. The UNCEEAA's medium-term programme was expanded. In addition to coordination (between groups and international agencies working on environmental-economic accounting) and methodological developments of the standard, the following were added: "database development", "implementation of environmental-economic accounting", "promotion", and "formulation of statistical responses to emerging policy issues". This corresponds to the desire of the Director of the UNSD (Stefan Schweinfest) to link the SEEA with the

Sustainable Development Goals (SDGs), the *Framework for the Development of Environment Statistics* (FDES) and business accounting in order to produce coherent information.

The UNSD proposed making governance more complex by creating new sub-committees and expert groups on different areas of work. Faced with the reluctance of several countries to make governance too complex, only "Technical committees" steering the research agendas of the central framework and experimental accounts were created. The first members of these committees are the editorial boards of the manuals completed in 2012 and 2013. It has been decided to open up exchanges with the scientific, economic and political communities:

"We were quite surprised by the widespread adoption of ecosystem accounts. A lot of people from different communities have started working on it. The manual has really filled a space. It came at the right time because I think a lot of people working on ecosystems thought that talking about it in isolation from economics wouldn't get them very far. And what we've done with the SEEA EEA is to link economic and environmental information." (Alfieri, pers. comm., 07/05/2021)

As far as the SEEA EEA is concerned, the areas of work listed in the Box 6 were accepted.

Box 6: Proposed areas of work for the SEEA EEA at the 8^e UNCEEA meeting

Short- and medium-term research priorities:
<ul style="list-style-type: none">- Spatial units- Methods for measuring ecosystem services and assets- Presentation and structure of the accounts and information in the accounts- Link with socio-economic data- Ecosystem services assessment
Medium and long-term research priorities:
<ul style="list-style-type: none">- Accounting concepts- Link between Ecosystem services and the state of ecosystems- Aggregation and indicators at ecosystem level

LG19 was a time to prepare for the future and discuss various technical issues (LG/19/minutes). Members expressed their willingness to continue working on ecosystem accounts, for example on the link between the FC SEEA and the ES SEEA and on the political uses of ecosystem accounts.

At the 9^e UNCEEA meeting, the medium-term work programmes for the SEEA FC and the SEEA EEA were discussed. The latter was divided into five work streams: "(a) Geospatial, relating to land classifications, delineation of statistical units, etc.; (b) Physical measurements of Ecosystem services and ecosystem condition; (c) Presentation and policy linkages; (d) Monetary valuation techniques and aggregation approaches; and (e) Integrated accounting issues". This agenda would be based on experiments launched in seven countries (the future ANCA project, funded by Norway). We can see that this research agenda makes no mention of cost-based approaches and that it aims to strengthen the sequence of accounts proposed in the ES EEA (in its appendix A6). This means that the study of alternative approaches is not part of the agenda and that the community considered that the previous controversies were over.

In parallel, an initial research project funded by the Norwegian development agency (Advancing Natural Capital Accounting Project; ANCA) was conducted to test experimental ecosystem accounts in

Bhutan, Chile, Indonesia, Mauritania, Mexico and Vietnam between 2014 and 2016. According to J.-L. Weber, the only person to give us details of this project, its ambitions were scaled back (pers. comm.). It did, however, lay the foundations for technical recommendations (United Nations, 2019) and to raise awareness of the new accounts in the project's host countries.

As always after a SEEA publication, it was time to take stock. The 21^e LG (2015) was an opportunity to establish its organisation for the coming years and to clarify the relationship with the UNCEEAA (after the sequence of 2012-2014 publications, the roles of the two groups seemed to overlap). The members agreed to maintain a certain degree of freedom and to exchange ideas more effectively. They should continue to work on the SEEA FC and experimental ecosystem accounts, as well as their implementation. An office will also be set up for the LG, comprising Eurostat, the WB, the Netherlands, the United Kingdom, Sweden, Italy and the FAO, all on a voluntary basis.

3.3.3.2. Organisation of the future review (June 2016 to December 2017)

At its 11^{ème} meeting in June 2016, the UNCEEAA reconfirmed that its role was managerial and strategic. As such, technical discussions should take place in Technical committees and London Group meetings and be brought to the UNCEEAA for decision.

A research programme was presented. We note that the "Presentation and links with policy" section has disappeared.

Regarding the SEEA EEA, he agreed to update it by 2020 and noted that it is ambitious, with drafting starting in 2018. The governance around the SEEA EEA has also become clearer. A Technical committee (TC) will soon be established, thus replacing as its primary role the editorial boards of the SEEA EEA (United Nations et al., 2014b) and the technical recommendations, which have already been drafted (United Nations, 2019). The TC was composed of Anton Steurer (Chairman of the TC, Eurostat), Carl Obst (Editor), Lars Hein (Wageningen University), François Souldard (Statistics Canada), Rocky Harris (DEFRA, UK), Jan-Erik Petersen (European Environmental Agency), Michael Bordt, Alessandra Alfieri and Julian Chow (UNSD), Gerhard Bouwer (Statistics South Africa), Steven May (Australia Bureau of Statistics), Sjoerd Schenau (Statistics Netherlands), the World Bank and the FAO. Jean-Louis Weber left the SEEA community at the end of 2015 and is therefore not a member of the committee.

The new priorities on the research agenda were technical issues (spatial units, ecosystem condition indicators, ecosystem services (ES), links between assets (and their condition) and the supply of ES, and monetary valuation of ES and assets). Non-priority issues include: the treatment of the atmosphere, ecosystem disservices, intermediate services and dependencies between ecosystems, the recording of activities that maintain or restore ecosystem conditions, and the definition and measurement of degradation.

At the 22^e meeting of the London Group, it was agreed that a three-year work plan would be proposed before the end of the year, together with a clearly drafted new mandate.

The 12^e UNCEEAA meeting was the last before the official launch of the review. It was an opportunity to present the final governance of the review. The research programme strands would be chaired by a member of the TC, and a lead author (selected through a paid consultation or partnership with an NGO or research institute) would prepare a working document based on the work of around ten experts in the field. The focus groups are as follows: spatial zones, state of ecosystems, Ecosystem services, valuation and accounting.

3.3.3.3. *The review process (2018 to March 2021)*

The particularity of this revision is that the London group had a completely marginal institutional role. Almost all the substantive elements were discussed elsewhere (at expert forums, expert meetings or meetings of the Technical committee on ecosystem accounts). Some experts traditionally present at the NPV attended, but many new personalities were principal authors of chapter drafts (in particular, Carl Obst, Peter Van de Ven, Bram Edens, Lars Hein, David Barton, Eli Finichel, Mandy Driver, Heather Keith, to name but a few). The discussion papers, which summarise the knowledge acquired in writing the chapters, were not presented to the LG, which remained the forum for presenting national feedback.

The review process officially began in 2018. Its launch was introduced by an expert meeting on ecosystem valuation in Bonn in April, at which experts and practitioners from a variety of backgrounds were able to present their ideas. The aim was to establish a dialogue between accountants, environmental economists and political decision-makers.

A number of national and European funding programmes contributed indirectly to the review. This is the case of the *Integrated System of Natural Capital and ecosystem services Accounting* (INCA; 2015-2020) and *Natural Capital Accounting and Valuation of Ecosystem Services* (NCAVES; 2017-2020) projects, which funded experiments and expert work.

A series of meetings followed (three expert forums, three LG meetings and four UNCEEA meetings). The Covid pandemic meant that meetings had to be held by videoconference, which may have slightly reduced the quality of discussions, but did not significantly slow down the revision process.

Although the structure of the ecosystem accounts has not changed, major improvements have been made in terms of content. Considerable work has been done on the extent and, above all, the state of ecosystems, thanks to the work of ecologists and geographers. It was also possible to specify and justify the use of Ecosystem services in an accounting framework. The process seems to have gone well before public consultation began in 2020. Once again, there were difficult negotiations on monetary valuation, to the extent that an extraordinary meeting of the UNCEEA had to be organised.

The complete manual was finally submitted to the United Nations Statistical Commission in March 2021 for approval.

4. Definition of the main controversies

A major difficulty encountered during the discussions, and highlighted by Radermacher (LG/5/pro, p.231; cf. Figure 30), is that people often jump from one scientific dimension to another, or from one sub-controversy to another. In this way, the discussion seems to follow a Moebius strip (O'Connor) in which all the subjects are covered in succession, without ever being able to stop: the technical feasibility of the evaluation, the availability of data, but also the norms internalised by each person as a result of their scientific training, the functioning of the actual or desired institutions in their own country, the place of science in political decision-making, etc. The discussion then moves on to the next.

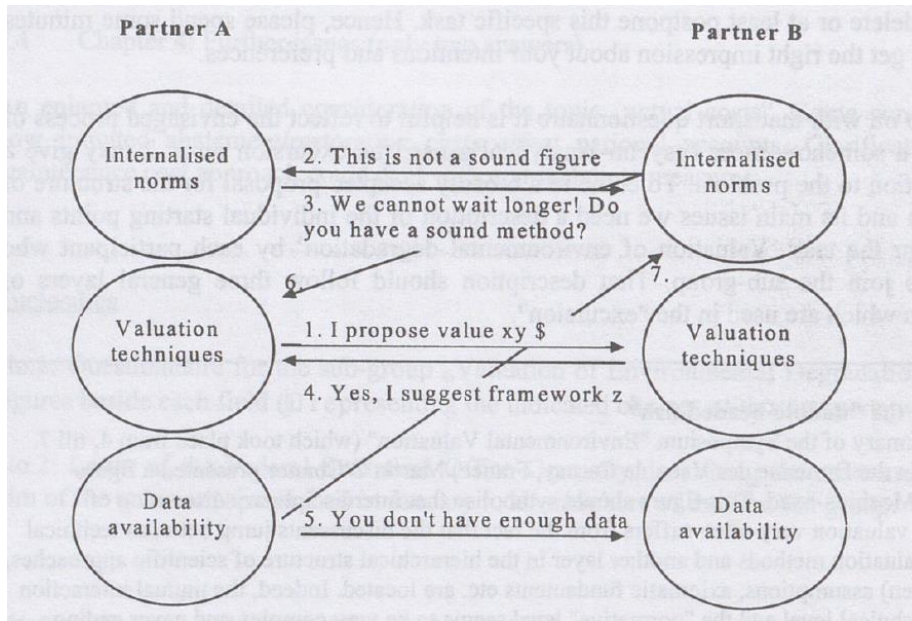


Figure 30 A typical debate on monetary valuation (source: LG/5/pro)

We therefore propose to disentangle and articulate four major sub-controversies on the subject of monetary accounts. During the thirty years of discussion, the discussions surrounding the SEEA have rarely taken place with such a strict separation of subjects. As we shall see, the experts most involved often defended a set of positions on these four areas of controversy. They considered them to be coherent and instantiated them in an accounting model that was often very complete (Genuine savings, greened-economy modelling, SEEA EA, etc.). However, the terms of the controversies have not changed much since 1993. This allows us to define them now to facilitate the reading of the following section.

Our study shows that a system of monetary accounts requires choices on the following elements:

- The unit of measurement, which may be physical or monetary;
- It is necessary to frame monetary valuation by making explicit the object that is the focus of attention. Two different frameworks have been proposed to date: costs borne and costs caused;
- Once the framework has been established, a concrete evaluation method needs to be used. The figures produced by each method have different levels of reality: they may involve strict observation or a greater or lesser degree of modelling;

- Once the value has been produced, it can be recorded in an account. This involves defining the account itself and its relationship with the other accounts (its position in the sequence and, because of the double-entry constraint, in which account the counterparty is to be found).

We can define the two opposite poles of the sub-controversy on the monetary unit as follows:

- Physical accounts: "if we had to choose between physical and monetary accounts, we would have to construct physical accounts first". A less well-represented variant of this position is "monetary accounts should not/cannot be produced".
- Monetary accounts: "If we had to choose between physical and monetary accounts, we would first have to construct monetary accounts".

The sub-controversy over the framing of the evaluation has evolved somewhat and deserves further explanation. We can define the two poles of the controversy as follows:

- Approaches based on the costs caused: "The approach based on the costs caused is the best way of conceiving monetary valuation".
- Approaches based on costs borne: "The approach based on costs borne is the best way of conceiving monetary valuation".

These terms were introduced by Jan von Tongeren in the SEEA 1993. They are defined as follows (United Nations, 1993a):

- Costs caused: "253 [...] costs associated with economic units actually or potentially causing environmental deterioration by their own activities". Using these costs, the analysis focuses "254 [...] on the immediate environmental impacts of economic activities".
- Costs borne: "253 [...] environmental costs borne by economic units independent of whether they have actually caused or might potentially cause environmental deterioration". Here, the analysis focuses on "254 [...] the state of the environment and its effects on human well-being".

We would stress that these approaches are distinguished by their focus: impacts on the environment or impacts on the economy. It is only on the basis of this initial framework that various monetary valuation methods can be used to obtain a numerical value. For example, the SEEA 1993 explains that the costs caused are assessed using the maintenance cost method⁸⁵. At that time, contingent valuation (and especially the estimation of willingness to pay) was the only method proposed for valuing the costs borne. Later, other methods were imported from environmental economics.

Subsequently, the approaches were renamed "cost-based" (costs caused) and "damage-based" (costs borne). (United Nations et al., 2003). Framing is presented in a slightly more vague way in this second version of the SEEA (there is no definition), but it refers to exactly the same idea. Several other synonyms have been proposed, but not adopted at the 6^e LG: damage caused and damage sustained, costs and benefits, supply and demand (LG/6/5i; LG/4/pro, p.5).

We define the poles of the data reality level sub-controversy as follows:

- Observation: "National accounting must stick to observation".
- Modelling division: "Modelling can be part of the national accounts".

⁸⁵ "Maintenance costs are costs that are necessary to prevent or mitigate deterioration of the natural environment. In the following paragraph: "they reflect actual or imputed market values" (United Nations, 1993a).

Other terms have been used to define this controversy: are we recording real values or imputed values? (United Nations, 1993a, para. 262) transactions or operations (Vanoli, 2005, chap. 4) observed or hypothetical figures (United Nations et al., 2003, p. 559) Are we doing accounting or analysis (Lange, pers. comm., 05/05/2021)? A similar, if slightly different, idea concerns the recording of past or future events.

The fourth sub-controversy concerns the accounting structure. As the relationships between the environment and the economy are numerous and sometimes complex, various options for integrating the environment into the accounts have been proposed. Three ways of integrating the environment into the national accounts have been discussed in depth in the SEEA process (especially the first two). Here we summarise the main choices proposed, giving them a title that reflects, in our view, the general philosophy of the account sequence:

- Imputing the unpaid cost of degradation (SEEA 93 IV.2): no institutional sector is created; environmental objects (ecosystems, etc.) are assets; production levels and GDP remain unchanged; degradation is defined as the physical deterioration of environmental objects⁸⁶; degradation is recorded as Consumption of fixed capital; a GDP adjusted for degradation is calculated.
- Revealing the value of the environment or nature (SEEA FC and EA): an institutional sector ("environment" or "ecosystem trustee") is created; environmental objects (ecosystems, etc.) are assets; ecosystem services (ES) are products of economic sectors or of the "ecosystem trustee" sector.) are assets; Ecosystem services (ES) are products of the economic sectors or the ecosystem trustee sector, production and GDP are increased by the supply of ES, ES are consumed as final consumption; degradation is defined as a reduction in the supply of ES, degradation is recorded as a Consumption of fixed capital; a GDP adjusted by degradation is calculated.
- Accounting for ecological debt (CGDD et al., 2015; Vanoli, 2012b) In this approach: an institutional sector (called "Nature") is created; environmental entities are outside the economy (and therefore not assets) and relations with them are recorded as debts; the definition and values of production, GDP and assets remain unchanged; degradation is defined as the physical deterioration of environmental objects; it is recorded as a transfer of capital from "Nature" (no new aggregate is created).

The 1993 decision to change the sequence of accounts in the System of national accounts (SNA) has long been at the heart of discussions. The idea of creating a completely different set of accounts did not go beyond that date. It involves adding accounts based on new data and correcting macro-aggregates and balancing items (GDP, income, savings, etc.). The authors propose (or not) to modify the definitions of the main concepts such as production and assets. The authors have always given their work the status of SNA satellite systems. This follows the first decision taken for the 1993 SEEA⁸⁷. They are therefore not afraid to propose substantial changes to the sequence of accounts and supply and use tables of the SNA.

In publications subsequent to the SEEA 2003, maintenance costs and ecological debts are presented as "other approaches", which would not be compatible with the SNA. This is also the case for genuine

⁸⁶ Please note: "Degradation in the SEEA refers to changes in the quality of the asset. In the Operational Manual, degradation refers to emissions, which in turn cause changes in environmental quality." (Alfieri, 1999, p. 5)

⁸⁷ In our view, another reason is that the SNA is already used for administrative and political purposes, such as the distribution of budgets and subsidies. This means that changing the SNA can have major financial and political implications.

savings (GS) (Hamilton, 2000, 1994). We describe maintenance costs and debt in this chapter because they were considered credible extensions of the SNA in early versions of the SEEA. In contrast, although true savings is close to National accounting and one of these aggregates is corrected, we do not describe it because it is related to wealth accounting, which is part of economics and not accounting. National accounting does not recognise the measurement of well-being, as it has regularly claimed since the 1980s. However, as we shall see, this approach has had a strong influence on the SEEA, particularly in terms of framing the monetary valuation of ecosystems.

We could also mention other frameworks, such as the NAMEA approach (see for example Keunig and de Haan, in Uno and Bartelmus, 1998) which was rapidly integrated into the SEEA, or the natural heritage accounts (Comolet and Weber, 1990) which have had a decisive influence in opening up the subject of ecosystems. However, these frameworks are mainly physical.

5. The treatment of monetary valuation in the the SEEA

This section describes the key sequences relating to the monetary accounts. Figure 31 summarises the key points in the evolution of the controversies.

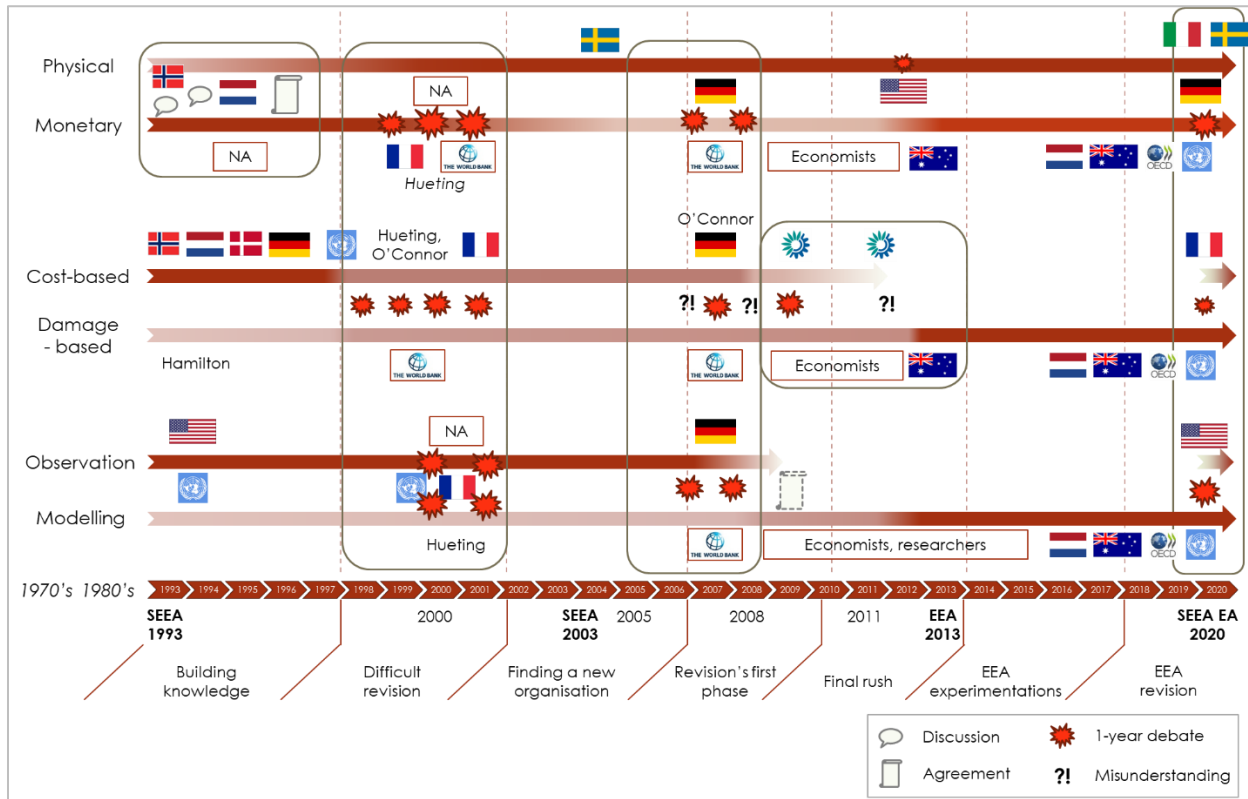


Figure 31 Evolution of controversies

Legend: The shade of red indicates the importance of the pole of controversy at a given moment in people's minds and research agendas. The bubbles are important sequences described in the article.

5.1.From SEEA 1993 to SEEA 2003

Chapter 1 described the three approaches of the 1993 SEEA. It was on this basis that the debates on monetary valuation took hold. The controversy over the unit of account arose from the lack of a clear biophysical basis in the SEEA 1993. The framework for monetary valuation was described for the first time, pitting two seemingly irreconcilable options against each other, even though they both provided important information for macroeconomics. The need to make this choice arises from the need for a single principle to guide the monetary valuation, so as to guarantee the consistency of the GDP adjustment envisaged. The question of modelling or imputations is a relatively old debate in National accounting. In principle, statistical offices must be independent of any political or normative influence in order to produce information that can be trusted. This rules out any choices on their part. However, it soon became apparent that, in the absence of observable markets to evaluate certain economy-environment relationships (or the state of the environment), major assumptions would be necessary, which in no way frightens economists for whom monetary valuation is indispensable.

5.1.1.Physical or monetary accounts and experiments on maintenance costs

Most of the experiments presented at the first LG were concerned with physical accounts, in contrast to the content of the 1993 IEEA, which focused almost exclusively on monetary aspects (LG1/pro). Many countries (France, Australia, etc.) have pointed out the difficulty of constructing monetary

accounts in the absence of adequate data. Three works on monetary accounts were nevertheless discussed.

Peter Bosch presented the work done with Hueting (a Dutch economist) on *sustainable national income* (SNI), an approach based on the costs of achieving environmental objectives, which can be used to calculate a green GDP. Several approaches were described: the SNI *per se*, which is based on a static estimate of the direct costs, potentially to be provided for by companies, which can be used to adjust GDP; the *national income in a sustainable situation* (NISS), which is based on much more extensive modelling to include indirect costs and therefore what the economy would be like if it were sustainable.

Kirk Hamilton (World Bank economist) proposes rejecting green GDP for adjusted net savings, taking a much more theoretical view. His method is based on contingent valuation of the damage caused by environmental degradation.

Finally, Knut Alfsen (Norway) concludes that the monetary approaches on which Norway has worked are difficult to present to decision-makers. Approaches based on repair costs required numerous assumptions to be made, which are almost a matter for political decisions, while those based on willingness to pay may be biased by the groups questioned.

Bartelmus and von Tongeren made it clear at the time that the aim of the SEEA was to create a common framework for monetary and physical accounts. Given that only three countries have worked in depth on these accounts and that this part of the SEEA is the least robust, it was decided to devote most of the following LG to work on the monetary question.

The focus of the following year's conference (LG2/pro) was the cost of reducing pollution. Two sessions were devoted to this subject. They included experiments conducted by Eurostat (Steurer), the Netherlands (de Boo, then de Boer and Bosch) and Denmark (Mollgaard). Radermacher, Vanoli and Kimio Uno made more general or theoretical contributions. The second session was largely based on the preliminary results of the Greenstamp project, funded by the European Union and involving France, Germany and the Netherlands. Lasting three years (1994-1996), its aim was to test and evaluate the consistency of approaches based on the costs caused (by the economy to the environment) with the SNA⁸⁸.

The connection with more traditional economic modelling (input-output models) is discussed in the 'applications' and 'other approaches' sessions. Also included is the work of Giles Atkinson and Kirk Hamilton (then at *University College* London) on the monetary valuation of health damage caused by air pollution.

In the final session, an initial list of unresolved issues was presented to guide future symposiums (presentation by Peter Bartelmus and Alessandra Alfieri, from the UN Statistics Division). There was a lively discussion on the relationship between the various monetary valuations. A strong idea emerged: "Different valuations answer different - and valid - questions, and it would be inappropriate to seek a single, universal valuation" (LG/2/pro, p. 400). But the constraint of an accounting framework turned

⁸⁸ The GARP (*green accounting research project*) project was financed by another EU fund over exactly the same period. Led by Anil Markandya and a British team, it aimed to estimate the cost of damage linked to air pollution, using the "costs borne" framework. Although O'Connor presented it to us as the other influential project, it does not seem to have any direct echo in the SEEA (not even Hamilton mentions it).

the second half of the sentence into pious hopes. Moreover, the reference to market prices remains unavoidable for National accounting:

"Market prices derived from actual transactions provide a solid basis that is consistent with other existing statistics. As we move away from imputed prices based on costs, modelling and simulation scenarios, the uncertainty surrounding valuations increases due to the assumptions made, the long time periods involved, uncertainty about future physical events, the preferences of future generations, etc." (LG/2/pro, p. 400).

We should also remember that the questions that have guided decades of work for the community were already being asked:

"Most of the time, we don't know what physical masses we want to measure." (LG/2/pro, p. 401)

"Another dilemma concerns environmental assets providing more than one type of service, such as forests providing timber, recreational services and climate benefits - if they can be measured separately, can they simply be added together? Or how can pollution in one period be linked to lower crop or timber yields in later periods?" (LG/2/pro, p. 401).

Finally, a short-term conclusion was to clarify the definitions of the various monetary valuation terms and approaches to enable a healthy dialogue. The articulation between them is considered equally essential to clarify the debates. In addition, the following future work was identified:

"Assessment of maintenance

- test the feasibility of compiling aggregate marginal holding cost functions (Radermacher 1995) and the validity of the approximation of average cost calculations;
- use/utility of the maintenance cost as a first step in internalisation (liability accounting, setting the levels of economic instruments).

Contingent valuation

- [given the well-known difficulties of aggregating⁸⁹ this type of assessment at national level, study] the possibility of obtaining information for regional accounting (Grambsch, Michaels and Peskin, 1993) or for specific areas.

Non-monetary valuation [in other words, physical approaches].

- link and compare experiences in the development of indicators/indices (NAMEA, UN/FISD, SCOPE, UNDP/HDI)". (LG/2/pro, p.406-407)

In 1996, at the third London Group meeting, O'Connor presented the conclusions of the Greenstamp research project, which were particularly interesting for understanding what followed. They clearly set out the points of reference for the discussion by distinguishing the poles of statistical quality: theoretical coherence, statistical rigour, relevance from the point of view of uses (which model, indicator, information for whom and in what context?), and the inclusion of an information system in an evolving socio-political process (LG/3/pro, pp. 417-418). However, as O'Connor notes (pers. comm.,

⁸⁹ Environmental economics had already made this clear (Kahneman et al., 1990; Kahneman and Ritov, 1994; Pearce, 1976).

04/11/2020), this has largely "gone unheeded"⁹⁰. Only those behind this project have fully drawn the necessary conclusions for their method. The others deviated little or not at all from their proposals. For example, Radermacher explains that it is possible for statistical offices to produce static abatement (or reduction) cost curves, based on marginal actions and not on the restructuring of the economy. On the other hand, as soon as normative objectives need to be defined (and the sum of the actions required to achieve them calculated, even in a static way), or large-scale reduction actions requiring strong hypotheses on the future development of the economy (with action scenarios, price trends, etc. based on dynamic reasoning), we leave the accounting framework behind.

Some elements of consensus are beginning to emerge on the place of modelling in environmental NA. Vanoli, as a National accountant with an intermediate position on the issue, pointed out that "if we accept the paradigm shifts concerning ecology and economics and if we are ready to place national accounts in the perspective of new problems, there is still a long way to go to translate this into practice. Furthermore, even if some aspects of the valuation are not acceptable, I would not totally abstain from the idea of valuing environmental change in the accounts" (LG/3/pro, p.347). The conclusion of the proceedings of the meeting mentions that: "a proper 'eco-GDP', estimating what GDP would have been *if* the economy had followed a sustainable path - in which all prices and quantities would have been different - could only be the result of an economic model, and not a simple accounting deduction as has often been suggested" (LG/3/pro, p.424). This was aimed directly at Hueting and Hamilton. Hueting eventually accepted that his methods were modelling, but he still wanted to apply his National accounting approach to the end (O'Connor, pers. comm., 04/11/2020). We shall see that Hamilton followed suit.

For his part, O'Connor is critical not of the monetary valuation, but of the aggregation of the environment into a single indicator. He explains that the correction of aggregates was neither useful (because "it says nothing about sustainability and there is no other reason to develop it") nor feasible within the framework of national accounts. The latter is due to "the impossibility of combining short- and long-term economic performance in a single indicator. Reasoning based on intertemporal general equilibrium models shows that using current prices (in the absence of valid prices on a sustainable consumption path) to calculate [environmentally-adjusted domestic product] or true savings can lead to false signals" (LG/3/pro, p.347).

Participants at the 4^e LG reviewed the structure of the SEEA and discussed the feedback from LG members and other stakeholders gathered by the UN on each part of it. One notable point was the discussion on the unit of account.

For a number of years, the Dutch have seen two currents clashing around the statistics institute (pers. comm. O'Connor, 04/11/2020; Lange, 05/05/2021; NPV, 30/06/2021). The first is Hueting's, with a modelling approach. The second was driven more by statisticians and National accounting. These, led by Steven Keunig and Mark de Haan, created the *National Accounting Matrix including Environmental Accounts* (NAMEA), or extended input-output tables. This involves adding physical environmental indicators to the traditional production and consumption aggregates in the monetary input-output tables. This enables us to remain within the framework of observation, while at the same time allowing for uses in terms of relevant economic and physical modelling. Linking physical data with traditional

⁹⁰ Until very recently. Several preparatory documents for the latest revision of the SEEA describe similar ideas.

accounting data in this way raised questions at a time when the central framework of the NA contained only monetary data.

It was therefore necessary to "overcome the apparent polarity between the SEEA and the NAMEA, to develop an integrated framework that includes input-output accounts, income and accumulation accounts and physical accounts, to focus on modules rather than versions" (LG/4/pro, p.5). This formulation was already a step forward, but for Bartelmus: "despite the apparent controversy, there is really no fundamental difference between the NAMEA and the SEEA since both are anchored in the SNA. A revised SEEA could include a NAMEA as one of its modules" (LG/4/pro, p.3). While the idea of basing adjustments to monetary aggregates on biophysical indicators now seemed fairly obvious (as we saw above), the controversy over the choice of unit of account also contained the problem of integrating other approaches. The conclusion of this LG on the NAMEA framework is an important element in resolving this discussion.

Another important session was devoted to environmental costs. Germany presented its experience of reduction cost curves in an accounting context. Statistics Sweden presented a comparison of the three monetary approaches described in the SEEA in three countries (Germany, Sweden and the Netherlands). In conclusion, these countries propose a "revision of the maintenance cost approach proposed in the SEEA. [...] An alternative use of cost accounting is proposed, a role in what is called a multi-criteria decision-making framework" (LG/4/pro, p. 7). It will articulate three types of approach: direct estimation of reduction costs, use of comparative statistics to estimate indirect costs and changes in prices, production and consumption; thirdly, a dynamic model would be used to estimate long-term effects.

Some members of the assembly went so far as to suggest that "since it is not possible to construct maintenance (or abatement?) cost curves for a full range of pollutants, a maintenance cost approach should not be specified in an environmental accounts framework" (ib.).

In retrospect, we can see that the conclusion of the Greenstamp project had mixed consequences for the cost approach: it clarified many points about the method and the appropriate frameworks for mobilising it, but it also highlighted weaknesses that it has not been possible to remedy subsequently. Faced with this, Radermacher, Schoer and O'Connor explored the possibility of multidimensional analytical frameworks, which are further removed from National accounting (or at least less familiar to national accountants) (see for example O'Connor and Schoer, 2009).

5.1.2.A complicated review against a backdrop of tension over currency valuation

The common framework with the physical and monetary accounts became much clearer and coherent from the 5^e London group, when all the approaches were presented jointly.

First, there are the various physical accounts, considered to be more or less important and achievable. The asset accounts (stocks) of natural resources⁹¹ include land use and its quality, biodiversity and the intensity of its use (LG/5/pro, p.51). Flow accounts can also be drawn up. The most aggregated are material flow accounts, the least aggregated are physical input-output tables. Secondly, mixed physical and monetary accounts are possible and particularly interesting: this is the NAMEA approach. Thirdly, monetary accounts include the recording of the depletion of natural resources and other environmental degradations (flows) which have an impact on asset accounts.

⁹¹ Norway and France were pioneers in this field (Theys, 1989 in Ahmad et al., 1989).

It was agreed that "there should be no explicit or implicit hierarchy between the physical and monetary accounts in the revised SEEA - the physical and monetary accounts should be presented schematically as a series of matrices linked to the standard SNA matrices" (LG/5/pro). However, Keunig and de Haan believe that the NAMEA approach is "as far as environmental accounting can go in terms of monetary valuation" (LG/5/pro, p.51). They state that "valuation of degradation is impossible if we are uncertain about the effects of degradation on human well-being and health. We should avoid pretending that accountants are able to estimate the effects of environmental degradation on income when science is still uncertain about the underlying cause-effect relationships" (ib.).

Similarly, with regard to monetary accounts, they feel it is important "to draw a clear line between the collection, estimation and presentation of ex post or descriptive data, for and in environmental accounts, and predictive or behavioural modelling loaded with assumptions." (LG/5/pro, p.53)

In an article entitled *Valuation of environmental degradation: Trying to stimulate a discussion*, Radermacher explains that "the difficulties are partly related to the fact that a valuation concept is not simply a technical matter. [...] we necessarily need decisions and priority selections that are based on axiomatic parameters and a compromise between different theoretical objectives, as well as the possibilities of practical realisation." (LG/5/pro, p.219) In line with Greenstamp's conclusions, he therefore proposes the following points (among others):

- "(2) The SEEA maintenance cost approach is used as the methodological basis.
- (5) GDP-adjustments are interpreted as the results of modelling, which is not (in many countries) a regular task for national statistical offices.
- (6) *Abatement* cost calculations carried out by statistical offices are an essential contribution to quantifying the technical efficiency of the economy.

Radermacher also carried out a survey to assess the opinion of the members of the London group. We note in particular the following result: "With regard to the conceptual treatment of natural degradation in the SEEA, the costs caused perspective with the maintenance cost approach is preferred, with some people proposing the integration of new concepts such as the damage cost approach in addition" (LG/5/pro, p. 229). Kirk Hamilton's point of view therefore still seems relatively isolated, even if Radermacher has tried to reconcile it (O'Connor, pers. comm., 04/11/2020). In reality, the results are quite clearly against contingent valuation, which is the proposed method for assessing such damage (Table 15).

Furthermore, "on the future role of statistical offices in the field of maintenance cost modelling, no clear decision is at hand. Depending on the national statistical organisation and the statistical laws, the answers differ widely" (LG/5/pro, p. 229).

Table 15 Critical review of various concepts relating to monetary valuation (source: LG/5/pro, p.222)

	valuation concept	characteristic feature	relevance for SEEA rev.
benefits	contingent valuation	actual individual preferences	no
	damage costs	estimation of economic repercussions in the future	no
	standards	social preferences as result of political decision processes	yes
costs	abatement costs of additional standards		yes

The following year, the LG presented the revision work underway. First drafts of chapters and lists of questions to be answered in the revision were discussed (LG/6/pro).

The sub-group on monetary valuation is made up of Sofia Ahlroth, Peter Bartelmus, Kirk Hamilton and Bob Harrison (Australia). The Germans, who have led the work on valuation since the beginning of the London Group, are not part of the group. Radermacher has left the LG, and Karl Shoer was working on the physical accounts. The people working on Hueting's approach were not present either. On the other hand, Anton Steurer had worked a little on these accounts and Bartelmus had views on this issue, but had not conducted any national experiments.

The reports indicate that the question of evaluation is still very controversial on several aspects: what should be described and recommended, its length, the unequal treatment of many questions and the parts that should or should not be extended (LG/6/5i).

During the session, Anton Steurer presented the monetisation frontier, devised with O'Connor. It expresses the idea that if the spatial scale, the level of aggregation or the importance of ethical or non-use values increase, monetary quantification is neither scientifically sound nor meaningful for policy (LG/6/5f).

Thus, two methods remain. Hamilton defended the dose-response approach (based largely on contingent valuation, which still has many shortcomings on a macro scale), using a welfare-based approach. The alternative approach, maintenance costs, requires modelling to be complete and interpretable in the way that was desired at the time. Bartelmus was probably one of Hamilton's main opponents. He wrote that "for reasons of data availability and compatibility with conventional accounting rules, maintenance cost and a simplified market valuation approach, 'net price', are considered to become the standard valuation in environmental accounting" and that "damage or welfare valuation should not be introduced into production-based environmental accounting" (Bartelmus, 1997). As modelling is outside the scope of statistical offices, he adds that "hypothetical costing of environmental impacts can be considered, however, as soft or descriptive modelling, a practice already common in [National accounting]" (ib.).

The coordinators of the revision found themselves in a difficult position. The chapter on monetary valuation still included lengthy "philosophical" discussions on the axiomatic points and objectives of valuation, without any definitive conclusions.

Compared to previous meetings, the place of damage-based approaches is changing significantly. It seems that Radermacher's departure has left more room for Kirk Hamilton, even though Bartelmus defended cost-based approaches. However, as O'Connor notes (pers. comm., 04/11/2020), the

institutional relationship between the UN and the World Bank must have played a role in explaining the greater recognition of damage-based approaches. On the other hand, the maintenance cost approach was not the subject of a broad enough consensus to be endorsed by the community.

If the UNSC minutes indicate that the Voorburg meeting (LG/7/minutes, May 2001) was very effective, it is certainly in relation to subjects other than monetary valuation. On this point, on the contrary, the meeting was extremely difficult (Lange, pers. comm., 05/05/2021)⁹². Although Rufie Hueting is not on the list of participants, it is possible that he attended the meeting, or certain parts of it. We can try to reconstruct the points of view and make assumptions about the exchanges on the basis of the interviews we conducted and the writings of each participant. There seem to have been three main opposing views: that of Rufie Hueting, the World Bank approach (Kirk Hamilton), and the NAMEA approach, or at least a more rigorous national accounting position, excluding the monetary approaches which seemed most interesting to the economists. This was to be led by Steven Keunig (who was supported by many other members).

"I don't think there was a good discussion between Hueting and the World Bank approach at all. It was very emotional. It was more a clash of thinking than anything else." (de Haan)

The debate between the two has taken various forms, concerning the theoretical underpinnings of their approaches, the aggregate to be corrected (GDP for Hueting, savings for Hamilton), and the framing of monetary valuation (Hamilton criticising in particular the "arbitrary reference point"; LG3/pro, p.389). On the other hand, their refusal to move away from strong hypotheses posed problems for non-economists.

Other more moderate members may have tried to intervene. Indeed, people like Bartelmus, Vanoli and the Americans were attached to monetary quantification, as they considered physical accounts to be insufficient. They continued to think about this afterwards, outside the SEEA. But unlike Hueting and Hamilton, they did not believe that such an assessment was the 'silver bullet', the key information needed to help decision-makers take the right decisions about the environment.

5.1.3. Results of the review: a manual that is not popular

The SEEA 2003, unofficially published in March 2004, received a mixed reception from the community that developed it and from the institutions that heard about it. It was a major step forward in terms of integrating biophysical statistics into an accounting framework. On the other hand, the monetary aspects and the general ambition of the handbook (to provide a framework for decision-making to achieve sustainability) were, for many, a failure. While it does set out a large number of experiments, the definitions have lost some of their clarity, and it is difficult to find a backbone to it. The cost and damage approaches are presented equally throughout Chapters 9 and 10. The relationship between the monetary valuation of environmental degradation and the system of national accounts is referred to... in an appendix, on the very last page of the manual! In the end, the three approaches mentioned (damage assessment, maintenance costs and modelling a green economy) are lumped together and rejected outside the framework of National accounting.

There is good reason to exclude all of them. Methods of quantifying damage necessarily include consumer surplus, which makes them a measure of well-being. Recording maintenance costs in a

⁹² "very very heated debate about valuation, and accounting vs analysis".

sequence of accounts does not work, as it is not possible to offset the new amounts charged (a problem linked to the accounting structure). Furthermore, if these costs were really compulsory, economic players would adapt their behaviour accordingly, which would lead to changes in prices and quantities on all markets. Finally, modelling the green economy (Huetting's approach) is seen as a useful tool, but it would not be the same as National accounting. It is an application based on accounting data.

This decision has an important consequence. From now on, it hardly seems possible to integrate monetary environmental accounts into National accounting, whatever approach is chosen.

The participants in the 8^e London group were clearly burnt out by the last exchanges and did not discuss the subject in 2003. The unresolved questions and avenues for future work emailed by Peter Bartelmus were certainly left aside⁹³. The subject was put on hold for a while, and attention turned to the new governance to be built for the next decade.

5.2.From SEEA 2003 to SEEA EEA 2013

With the renewal of the SEEA community, which saw the departure of figures such as Vanoli, Bartelmus, Steurer and many national accountants, the discussion on monetary valuation changed radically. This was not to be expected at the time, but discussions and fundamental advances on the subject virtually disappeared until 2010. At that point, and in the final rush to produce revised manuals, the mobilisation of new experts on the subject (mainly Australian and Dutch) made it possible to choose an approach to environmental degradation that would be applied to ecosystems. The accounting structure will be very similar to the 1993 version.

5.2.1.Tense talks to take over monetary accounts research

Three trends emerged between 2005 and 2009:

- Difficult discussions took place about the relevance of the World Bank's approach (genuine savings), particularly with Germany. For Walter Radermacher, "it was very unpleasant, one of the great emotional battles. The proponents of this neoclassical concept claimed to be able to shape the direction of the SEEA as a whole. However, this contradicts the majority approach of designing a framework within the SEEA in which different methodologies could be harmoniously linked in parallel." (pers. comm. 16/08/2021). This proved to be a dialogue of the deaf. No new arguments were put forward and the research agenda stalled for almost five years (ten if we start from the last discussions in Voorburg, in 2001). The questions were indeed epistemological, and no satisfactory solution was found.
- Jean-Louis Weber anchored his position in the SEEA and defended the ecosystem approach. Previously, this had been secondary. This change was closely linked to the new international dynamic (outside the SEEA) on the subject. He proposed an assessment based on restoration costs. He also put forward the concept of Ecosystem services.
- The structure of the future SEEA was decided. This is fuelling part of the debate on monetary valuation.

With Radermacher's return to the community, Germany presented a document at the preliminary meeting of the UNCEEA in 2005. In our corpus of texts, this is the most remarkable synthesis on the subject, together with that of Bartelmus (2013). It states that monetary valuation should be seen as a

⁹³ He then retired and was replaced by Alessandra Alfieri.

long-term problem, as there is no easy way to solve it. The final choice is based on positions regarding "environmental problems considered most pressing [...], institutional arrangements, user needs [...]. Perhaps even more important are the differences in the theoretical basis and axiomatic background of the proponents of the two orientations" (UNCEEA/Prelim/2/9e). As a result, the Germans believe that further research will not be useful. He warned the SEEA community against "harbouring false hopes that the differences [...] could be quickly overcome. Nor is it wise to reach a solution by changing majorities on the LG committee" (ib.). Instead, they suggest testing all monetary approaches in one or more countries to compare them in the same context on a few environmental issues. They believe that "in the end, the needs expressed by international and especially national users will decide which approach will be used for national accounts in practice", and that "a sustainable and permanent demand from users [...] must develop as a prerequisite" (ib.).

The minutes do not say whether the LG endorses the idea of testing all monetary approaches at the same time, but we find it in the appended research programme. The future UNCEEA agreed to classify the subject as a long-term issue, but also asked the US Bureau of Economic Analysis (BEA) to provide a paper setting out alternative views. Apparently this paper was never drafted, but the World Bank (WB) presented some ideas at the next meeting. At that time, the WB and the BEA agreed on the need to create monetary accounts (Lange, pers. comm., 05/05/2021). It is therefore possible that the BEA referred the matter to the WB. On the other hand, Germany and the Netherlands were against their inclusion in the National accounting (ib.).

A second scene in this sequence took place in June 2006 with LG10 and UNCEEA1. The LG10 meeting set a new agenda and a new objective: to resolve the methodological issues to raise the SEEA to the status of a statistical standard. The new governance of the LG was presented, along with a consolidated list of questions. The list of questions drawn up at the UNCEEA1 (22-23 June) includes a paragraph on evaluation, drafted by the German Statistical Office. It takes up the conclusions of the previous meeting⁹⁴ and lists the issue as a "long-term" one.

Kirk Hamilton presented a "*Summary of the issues [on valuation] in the research agenda*" (LG/10/minutes), which means that he was informally in charge of the research agenda. His presentation is not available, but from the summary of the meeting, and what he presented at the subsequent UNCEEA meeting, we assume that he made the same presentation at both meetings. If this is the case, his presentation was in contradiction with the paragraph of the consolidated research agenda prepared by the German Statistical Office (see next meeting).

The minutes state that "40. The London group noted that monetary valuation is the most controversial topic on the research agenda and recommended that the issue be discussed by the UNCEEA. It endorsed the proposed list of issues, but expressed concern about their classification as a "short-term" topic. He noted that Chapters 9 and 10 of the SEEA need to be substantially rewritten to better reflect the economic assessment and its relationship to the 1993 SNA assessment" (LG/10/minutes).

⁹⁴ "The SEEA-2003 presents three approaches to the assessment of degradation, namely the damage cost, the maintenance cost and the modelling approach. These three methods represent different concepts and philosophical approaches to analysis. While further research in this area would certainly promote a much-needed standardisation process, it does not seem plausible that these approaches can be reconciled. There is very little practical experience of assessing degradation in an accounting context. To date, only a few countries have experimented with the techniques recommended in the SEEA, and no country has implemented all three approaches and compared the results against environmental accounting. It is therefore suggested that a pragmatic approach be adopted and that a few pilot studies be set up to test the different approaches" (UNSD, 2006a).

The World Bank has officially taken the lead in the monetary valuation research programme and a sub-group has been set up. Canada, Germany and Glenn-Marie Lange have volunteered to join.

Despite the positions of its new president, Radermacher, the UNCEEA agreed to leave the door open to monetary valuation. Radermacher explained that, although monetary indicators and accounts are necessary, the SEEA should abandon the idea of a single indicator correcting GDP and work on broader information systems.

Later, after the presentation of the general research agenda, Kirk Hamilton presented his list of questions on monetary valuation. He proposed that the calculation of maintenance costs and the modelling of the green economy should be presented in Chapter 11, as applications. These two methods should no longer appear as accounting concepts. Instead, he proposed the following: "Valuing degradation then becomes a matter of valuing the damage to assets (produced, natural or human) associated with the use of the environment - it is akin to the Consumption of fixed capital" (UNSD, 2006b). It classified this issue as "short-term" and proposed new questions related to this approach. It also left the paragraph previously drafted by the German Statistical Office in the "long-term" category. The UNCEEA preferred not to comment on this contradictory research agenda, but simply "took note" of it (UNCEEA/1/minutes). It was the next LG that decided which way to go.

At the same time, the other themes on the research agenda were officially distributed to volunteers. For example, Jean-Louis Weber took over as head of the "Land and ecosystem accounts" sub-group created at the LG, which should include experts from communities other than national accountants.

The most significant elements of the 11^e London group are the discussion on a structure for the standard (Box 7) and the drafting principles. The members thus decided to include in the standard the elements on which there was consensus and for which practical experience was well advanced. It is reiterated on several occasions that "a standard must not take sides with different schools of thought" (LG/11/3a). The standard must provide definitions, describe the accounting structure and aggregates, and propose tables and classifications. Examples, references to research and names should be removed. It should confine itself to statistical issues and thus not be aimed at a policy audience (the third part of the SEEA is devoted to them, not the rest). This means that a discussion of sustainability as proposed by the German Statistical Office as an "objective function" at the previous UNCEEA meeting (UNCEEA/1/5)⁹⁵ will not appear in the introduction, but in the third part.

⁹⁵ Radermacher presented a paper on strategic issues in environmental and economic accounting (UNCEEA/1/5), in which he proposed that the system should have a clearly identified function. This could be 'keeping capital intact' or 'maximising the productivity of natural inputs'. This function should be consistent with the needs of the users and should address the relevant issues of sustainable development. This recommendation was accepted in principle, but not acted upon. At UNCEEA 2, still chairman, Radermacher asked members to give him their comments and to continue discussions within the new UNCEEA bureau on the strategy paper he presented at the last UNCEEA meeting.

Box 7: Proposed structure of the revised SEEA (LG/11/3a)

1. Introduction;
2. Structure of the SEEA;
Part I Statistical standard
3. Physical flow accounts (and their link with the national accounts);
4. Accounting for environmental activities and income;
5. Natural resource balances; optional breakdown:
5a. Balance sheets in physical terms;
5b. Balance sheets in monetary terms;
6. A complete sequence of current accounts and monetary accumulation accounts (including balancing items corrected for resource depletion).
Part II Experimental accounts and applications
7. Techniques for assessing environmental degradation;
8. Accounting adjustments for environmental degradation;
Part III: Political applications and uses
9. Political applications and uses.

As far as monetary valuation is concerned, the German Statistical Office is preparing a document with a new organisation of chapters 9 and 10⁹⁶. However, due to the very different list of questions presented by the World Bank (The World Bank, 2007) at the UNCEEAA2 meeting, the German Statistical Office and the World Bank were invited to prepare a joint paper on monetary valuation issues (UNCEEAA/2/minutes).

Until the 12^e London group, work on ecosystems was marginal and remained excluded from the overall reflection. Despite the creation of a dedicated group, there was no chapter describing ecosystem accounts in the future SEEA and the subject was always discussed at the end of meetings. It should be noted that the document prepared by the World Bank for the last UNCEEAA (The World Bank, 2007) mentions the evaluation of Ecosystem services. In fact, Mr Weber mentioned that, although the World Bank had its own agenda on Ecosystem services, they both agreed on the need for their physical accounting (pers. com.). At this meeting, Jean-Louis Weber presented a document (Weber, 2007) presenting options for integrating these accounts into the current SEEA, in both physical and monetary terms. Ecosystem services and the cost of maintaining them were presented. This was the starting point for the growing recognition of ecosystem approaches in the process.

At that time, the structure of the SEEA was rediscussed, but there is no mention of the monetary valuation of degradation because the subject "is still under strategic discussion within the UNCEEAA" (LG/12/minutes).

In June 2008, the third meeting of the UNCEEAA marked a major turning point in ecosystem valuation and accounting. The meeting documents include the minutes of the UNCEEAA Bureau. We learn that they decided to "address the issue of monetary valuation and propose a way forward" (Bureau/1/minutes). First of all, an initial avenue was ruled out:

"The proposal to organise a meeting with the academic world with the aim of advancing the discussion on the theoretical foundations of the SEEA and in particular on evaluation was not supported. Board members expressed concern that the meeting would rehash past

⁹⁶ Schoer and O'Connor prepared the document (O'Connor and Schoer, 2009) but did not complete it until two years later. By then Radermacher had left, so it was never discussed at SEEA meetings. The approach described is very different from National accounting.

discussions, with advocates of different schools of thought maintaining their positions without reaching any conclusions". (UNSD, 2008).

However, the UNCEEAA has concluded that a new group on monetary valuation will be made up of members of the SEEA community, as the issue has not progressed. This group should "be given clear direction on the issues to be addressed to keep the agenda manageable and avoid reopening old debates" (UNCEEAA/3/minutes). The UNCEEAA board will draw up the group's terms of reference. The World Bank would take the lead.

Secondly, an important substantive decision has been taken, based on a paper presented by the UK at the last London Group. Volume III "Applications and Extensions" will focus on the policy uses of Volume I (the future central framework). This decision will only have consequences a little later, but let's remember Hamilton's proposal to move maintenance costs and green economy modelling to volume III. If they are no longer in volume II and volume III excludes what is not anchored in volume II, they will automatically disappear.

Finally, the UNCEEAA took a serious look at ecosystem accounting. The committee admitted that it was premature to decide whether or not this approach should "take over from the work on volume II" (UNCEEAA/3/minutes). Some topics will be included in Volume I, and those concerning valuation will appear in Volume II.

Radermacher's departure from the presidency of the UNCEEAA and the SEEA community in general came at this time. With his replacement by Peter Harper (Australia), the whole balance changed. Mr Schoer left a few months later (after the 13th London Group, where he presented a document unrelated to the evaluation), and Mr Kuhn did not take up the positions of his predecessors. This means that after the heated debates that took place between the two Germans and the World Bank, the latter remains alone in expressing its point of view on monetary valuation. Mr Weber proposed using maintenance costs, but he never defended this approach as strongly as physical accounts (O'Connor, pers. comm., 04/11/2020). In fact, he has even proposed a radically different way of quantifying an ecosystem value, using a composite physical measure (Weber, 2014).

Moreover, as it was clear that volume 2 would not be part of the standard, "it probably did not generate the debates it should have. They did take place, but in the second iteration of ecosystem accounting [after 2015]" (Carl Obst, pers. comm., 10/05/2021). We shall see later why these debates actually took place in quite different terms.

5.2.2. Exclusion of cost-based approaches and creation of a new consensus

At the meeting of the 14^e group in London in May 2008, Glenn-Marie Lange presented an updated list of questions. The "benefits/damage" and "maintenance" approaches will be distinguished, but the emphasis is on the first approach in future questions to be worked on (which will soon be confirmed). In particular, Ecosystem services are described as a potentially interesting framework. It proposes a list of members for the Valuation Advisory Group, including: the World Bank (Kirk Hamilton, Glenn-Marie Lange and Giovanni Ruta) to lead the group, Giles Atkinson (London School of Economics), Jeffrey Vincent (Duke University), the Australian and Dutch statistical offices, the *Bureau of Economic Analysis* (USA), the UNSD (UNDP), the World Bank and the World Bank.U.), UNSD, the United Nations Environment Programme (UNEP) and the European Environmental Agency (EEA; in the person of J.-L. Weber) (LG/14/minutes).

During the 4^e UNCEEAA meeting, the World Bank presented a document describing the possible content of experimental ecosystem accounts (The World Bank, 2009) oriented solely towards the evaluation of ecosystem benefits (according to the damage approach, or costs borne). In fact, the working group no longer includes statistical offices or the EEA (Weber), but only members of the WB, the UNSD and consultants⁹⁷. UNCEEAA members pointed out that information on the costs of maintaining ecosystems may be needed to complete this approach, as it is relevant to public policy. They also asked the WB and UNEP to work on ecosystem accounts and classification based on the initiative *The Economics of Ecosystems and Biodiversity*⁹⁸ (presented during the meeting) and of the Millennium Ecosystem Assessment (2003).

At the 15^e LG, the World Bank presented ideas on assessing degradation. It presented the same document as at the last UNCEEAA meeting. The authors explained that this work was part of the WB's environmental strategy. The focus is on ecosystem services and assets, based on the classifications of the European Environmental Agency (EEA). However, the EEA, notably through the voice of Mr Weber, has expressed concerns about the general approach and has proposed an assessment based on changes in the state of ecosystems and the cost of maintaining or restoring them (and not on lost benefits). The LG shared Mr Weber's concerns and agreed on the importance of a balanced view. The Volume 2 process should therefore be "carefully moderated" (LG/15/minutes)⁹⁹. The EEA will provide a paper to the WB, which "should actively engage other partners" in this work (LG/15/min). Finally, the timetable proposed by the WB was tightened.

Weber then presented his work on accounting for physical ecosystems. Following a presentation by Peter Comisari (Australian Statistics; at that time acting editor of the SEEA), who proposed a framework and a list of questions to be included in volume 2, Weber stressed the need to construct a proper volume 2 that would not simply aim to "collect the rubbish from volume 1" (LG/15/minutes). This point was broadly endorsed. The LG proposed the following structure:

- "(a) Ecosystem accounts and Ecosystem services;
- (b) Valuation techniques for measuring environmental benefits and damages and their application in a national accounting context (excluding depletion of natural resources which is already covered in volume 1);" (UNSC/41/LG).

Despite what is suggested by the mere use of the term damage (which is significant in this context), approaches based on (caused) costs have not yet been completely ruled out.

In May 2010, Carl Obst was appointed Editor-in-Chief of the SEEA. In June, the UNCEEAA 5 meeting took place. The experts agreed on the structure of volume 2 and recognised that the ecosystem approach "could be a very important extension of the SEEA" (UNCEEAA/5/minutes). They asked the WB, the EEA and the UNSD to produce a roadmap for this volume.

With regard to monetary valuation, Giles Atkinson (hired by the WB as a consultant) and Weber sent documents. They followed on from the April 2010 meeting organised by the WB. However, the presentation made by the WB consisted of only four very superficial slides. UNCEEAA is concerned about the WB's ability to take the research agenda forward. It urged the WB to produce a list of research questions quickly (UNCEEAA/5/minutes) and to update the Atkinson paper.

⁹⁷ Giles Atkinson (LSE), Jeffrey Vincent (Duke University) and Charles Perrings (University of Arizona).

⁹⁸ Global initiative to make the value of nature visible ([website](#)).

⁹⁹ It seems that the task was then entrusted to UNSD.

During LG16 in Santiago, Volume 2 seemed to be on track. The World Bank had shortly before obtained funding to work on monetary valuation and to do case studies. Someone mentioned that this could help move the research programme forward quickly. The WB and the EEA are going to work closely together to draw up a list of questions, which is crucial. Regarding the unclear status of the handbook, particularly in relation to volume 1, the LG asked for clarification from UNCEEA.

It was agreed at the time that volume 2 would deal with ecosystem accounting, defining physical and monetary stocks and flows. Marian Delos Angeles (WB) presented an outline of the valuation section¹⁰⁰. The outline itself is not available, but we assume that it is very close to the paper written by Giles Atkinson that appears in the proceedings of this meeting (the ideas described are almost identical to the previous version of his paper). The LG "supported the new approach in Volume 2, moving away from the emphasis on degradation assessment and focusing more on the systems approach" (LG/16/min).

The following day, Frédéric Nauroy (French Ministry of the Environment), presented ("for information") the follow-up to the Stiglitz Commission (Stiglitz et al., 2009b). He also presented a document setting out the Unpaid Ecological Costs associated with carbon emissions. This calculation is based on the Vanoli approach (Vanoli, 1995). The LG simply asked him to be informed of these developments and announced that the document was potentially relevant for volume 2. This non-committal response is certainly linked to the erratic presence of the French in the year 2000.

The first expert meeting on ecosystem accounting took place in May 2011. This group brings together people who want to be more involved on volume 2, in addition to LG and UNCEEA meetings. A major development was that Michael Vardon (ABS) presented a paper on the approach developed in Australia. This paved the way for greater Australian involvement in the drafting of Volume 2. The UNSD was also heavily involved.

At the BA6 in June 2011, the UNSD presented a roadmap for what is now called Experimental Ecosystem Accounts. It described the growing political demand for ecosystem data and valuation, the structure of the future manual (conceptual framework, physical assets, physical flows and monetary valuation) and a work plan. The UNCEEA approved the approach, but requested further details and clarifications (notably on the objective and scope of the valuation) for the next meeting. The approach to monetary valuation was in fact rather unclear, with the authors still being cautious:

" 32. [No full valuation of ecosystem capital is planned at this stage beyond the valuation of assets that are at the same time economic assets and recorded in the SNA. However, the possibility of collecting data from existing statistics and administrative reports on the benefits of services and the costs required to restore Ecosystem services capital after degradation will be explored" (UNCEEA/6/6, prepared by UNSD, EEA and the World Bank).

The UNCEEA approved the proposal to involve scientists, statisticians and economists working on the environment.

We can already see that this roadmap has marked a turning point for monetary valuation. First of all, it is limited to the field of ecosystems; other environmental issues are not mentioned. In addition, degradation is not as central as it was. Ecosystem services, on the other hand, play an important role, particularly in physical accounting (flow accounts). In monetary accounts, the cost and damage approaches are on an equal footing, defended respectively by the EEA and the WB.

¹⁰⁰ We were unable to access this document.

At the LG's next meeting in September 2011 (LG17), many members wanted to get involved in preparing ecosystem accounting. However, the LG's own task was limited to safeguarding the link between the core framework and ecosystem accounts, as a dedicated technical expert group would write the chapters. The LG warned "against presenting ecosystem accounting as leading to the valuation of ecosystem degradation and an environmentally-adjusted aggregate, although this is not ruled out at this stage". Managing expectations was seen as very important in this respect" (LG/17/minutes). For Mark de Haan (pers. comm., 19/05/2021), this is a reminder that some environmental accountants wanted to develop ecosystem accounting for its own sake. In particular, they knew that the valuation of many Ecosystem services was not easy. And completing the GDP correction beyond resource depletion by ecosystem degradation would not be easy.

The expert meeting on ecosystem accounting is a crucial moment for monetary valuation (EM/2011-2/minutes). The (new) thread running through the presentations on monetary valuation is the constraint of consistency with the SNA. Three papers were presented at the session on valuation¹⁰¹.

- An article by Pittini (2011, p. 13) (UK DEFRA): under the title of 'cost-based approaches', the author presents an approach that is completely different from the one that has prevailed until now. The aim is to assess the costs of (re)producing ecosystem goods and services. No link is made with the impact of the economy on ecosystems. Under this title, we find exactly the opposite framing ("damage-based approaches"). In this article, the distinction between cost-based and damage-based approaches relates to the precise methods of evaluation, rather than to the prior framing of the evaluation. Thus, the costs of restoring ecosystems are classified in the same category as opportunity costs, alternative costs or replacement costs. It is the mere presence or absence of the term "cost" that defines the approach, rather than the relationship between the economy and the environment that is to be assessed (impacts or Ecosystem services). This change in the definition of the monetary valuation controversy has remained with us to the present day. Whether voluntary or not, redefining the subject of controversy always has a major impact on its evolution (Lemieux, 2007; Seurat and Tari, 2020). In this case, the consequences are to render one pole of the controversy invisible by reducing it to a sub-category of the opposite pole.
- An article by Eigenraam et al (2011) The authors describe the market-based instruments developed in Australia and examine how these markets could be mobilised for monetary valuation in the accounting framework. They also recall the principles used in the central framework, chosen to be consistent with the SNA. Thus, the definition of an asset as a store of value, economic ownership and valuation in the form of NPV are highlighted and proposed as a method for ecosystems. Consequently, they implicitly propose to make no distinction between ecosystems and the resources of the Central Framework (water, minerals, energy, land, wood, etc.).
- An article by Simpson (2011) (US EPA): presents a balanced and factual point of view, without entering into the cost/damage debate in the terms used to date. The analysis is made from the point of view of an economist. He begins the discussion with the notion of capital. His conclusion is that the value of preserved or restored land "cannot currently be assessed with anything approaching the precision obtained by recording actual market transactions". He therefore

¹⁰¹ It is at this point that the SEEA is confirmed as belonging to the wealth approach. If we go back to the analytical framework proposed by Riege-Wcislo and Steurer at LG4 (LG/4/pro, p.92), we can understand this choice as a rejection of the "external effects" approach in favour of the "national wealth" approach. They explain that the latter approach is more relevant for resource-rich or developing countries, while the former is better suited to industrial countries with high rates of degradation. This could be another reason why the WB has developed the wealth approach.

advocates continuing to value land-use change in a physical way and continuing research, "to put this form of natural capital on an equal footing with investment in manufactured capital".

The minutes show that the terms of the discussion were not the same as at previous meetings. There was very little mention of approaches based on costs and damage, and if there was, they did not cover the same ideas. In addition, the focus is almost entirely on Ecosystem services, and not on degradation. Lange concluded the session by saying that valuation techniques should remain consistent with the SNA concept of value (i.e. market/marginal values) and that cost-based methods are "third-best" approaches.

Mr Weber made no presentation at this session, although he did at several other sessions (on the structure of the accounting system and physical accounts). Strangely, the minutes do not mention the arguments of the Canadian paper attached to this session, despite its opposing views on monetary valuation: this paper concludes that cost-based approaches are closer to the SNA than the valuation of Ecosystem services.

Prior to the next expert meeting in May 2012, the SEEA EEA editorial board was formed in March from: Carl Obst (Chair), Micheal Vardon (ABS), Warwick McDonald (Australian Bureau of Meteorology), Michael Bordt (Statistics Canada), Anton Steurer (Eurostat), Glenn-Marie Lange (World Bank), Jean-Louis Weber (European Environmental Agency), Lars Hein (Wageningen University, Netherlands). He prepared a draft outline and brought together the contents of each chapter for discussion. We note that Weber presented nothing in May 2012. He explains that he was 'unofficially removed' from the editorial board because he expressed different opinions (pers. comm., 17/06/2020). This event is significant for the future course of the SEEA. He was the last to work actively on cost-based approaches.

At the expert meeting, important papers on accounting structure (C. Obst), monetary valuation (L. Hein) and the sequence of accounts (Edens and de Haan) were presented. The aim was to "review the key issues in the light of new research [...] and to examine the draft framework and content for the SEEA's experimental ecosystem accounts" (EM/2012/minutes). Compared with the last five years, this represents remarkable progress. However, for Carl Obst (pers. comm., 10/05/2021), this was only the first step: "There was so much to take care of between 2010 and 2013. The idea was to draft something that would avoid a deadlock". The structure and content of the SEEA EEA remained unchanged until its publication. The end of the process was to write the chapters. The monetary valuation and the sequence of accounts were then strengthened, but these elements, laid down in haste, remained the backbone of the 2020 SEEA EA.

In his presentations to UNCEE 7 and 18^e LG, Carl Obst pointed out that monetary valuation remained an outstanding issue, although the chapter was making good progress. In particular, it remained to be seen whether the different methods (market prices, declared and revealed methods) were compatible with the principles of the SNA. It is still difficult to define the sequence of accounts and its adjusted aggregates in a way that is consistent with the SNA. At the 18^e LG, he proposed discussing alternative methods for measuring degradation: restoration costs of changing the value of expected flows of ecosystem services. Brams Edens initiated a similar discussion, asking, for example, whether degradation should be a physical or a monetary concept.

A final presentation of the SEEA EEA before approval took place in November 2012, at an international seminar entitled "*Toward Linking Ecosystems and ES to Economic and Human Activity*". At this meeting, Walter Radermacher, then Director General of Eurostat, explained in his opening speech that the monetary valuation approach chosen was a "bad idea" because the methods required were outside

the scope of work of statistical offices (IS/2_73). This was a reminder that the controversies over valuation were not entirely over, despite the forthcoming publication of the SEEA EEA.

Finally, in March 2013, the manual was submitted to the 44^e session of the United Nations Statistical Commission for comment and approval. It sets out the future structure of ecosystem accounts, but remains a very preliminary version. Ecosystems are referred to as "ecosystem assets". Although their biophysical state is the subject of a separate chapter, the definition of degradation in the monetary sense is linked solely to the loss of Ecosystem services. A Net present value can therefore be calculated for the future benefits expected from each ecosystem.

For Radermacher, "the World Bank defended this particular neoclassical scientific approach and wanted to encourage the whole community to follow it. But they failed" (Radermacher, pers. comm., 18/08/2021). The discussion between the sub-controversies that we are proposing leads us to qualify this: although the World Bank was unable to get the addition of genuine savings accepted, the framework of monetary valuation that it defended was adopted in its entirety. Carl Obst sheds light on this choice and the origin of the consensus that was formed:

"We had sufficient support for this, not least because of the environment of the Millennium Ecosystem Assessment, *The Economics of Ecosystems and Biodiversity* (TEEB), the UK National Ecosystem Assessment, around 2010. All of these have contributed to a better accounting of wealth and a more Ecosystem services-based perspective. So, in a sense, we have jumped on this potential, to create an integrated accounting story." (Carl Obst, pers. comm., 10/05/2021)

5.3.From SEEA EEA 2013 to SEEA EA 2020

After 2012, we will focus mainly on the SEEA EEA. In the SEEA FC, the monetary valuation of the environment has stabilised around the Net present value of natural resources. The research programme aimed to refine the classifications of expenditure and green activities, to clarify the recording of natural resources, to provide guidance for implementing the accounts and to link them to other frameworks (SNA, FDES, etc.).

At that time, there was no breakthrough in the monetary valuation of ecosystems. The work undertaken during this period consisted of better justifying the foundations laid around 2011 and refining the valuation methods and accounting structure adopted for ecosystems. The issue of modelling (imputations) was simmering under the ashes throughout the period. As most of the experts involved were not National accounting experts, they paid little attention to this issue. When this was the case, only the angle of data quality (to better measure their purpose) was followed. The question of the institutional possibilities of statistical offices was not discussed. We will nevertheless highlight the rare discussions on this subject.

5.3.1.Almost complete consensus on the monetary accounts experiment (June 2013 to end 2017)

The areas of work proposed at the 8^e UNCEEAA meeting mention the evaluation of Ecosystem services as a short or medium-term priority. The structure of the accounts was classified as a medium- to long-term issue. There were few events to punctuate the discussion on monetary valuation in the early years.

The opening up to research has had the effect of encouraging the SEEA's main experts to publish in academic journals. Thus, alongside the increasingly rigorous description of the principles to be followed for the monetary valuation of ecosystems, arguments are listed to show the inadequacy of cost-based approaches in this framework (Edens and Hein, 2013; Hein et al., 2016; Obst et al., 2015; Obst and Vardon, 2014)sometimes giving rise to debate (Droste and Bartkowski, 2018). Surprisingly, the Dutch and Australian authors of the SEEA do not cite the very clear paper on this controversy by Bartelmus (2014)¹⁰².

One of the ways in which the community opened up to research was through the creation of an expert forum (part of the ANCA project), the first of which was held in April 2015. It brought together the issues to be resolved to strengthen the SEEA EEA. A first version of the technical guide (the future technical recommendations) on the SEEA was presented. Among the conclusions drawn at the time was that there is a "significant challenge in separating ecosystem values from current values in the SNA". Indeed, most of the services provided by ecosystems are already included in current prices, and the challenge is to reveal them, make them visible and separate them in order to quantify nature's contribution to GDP. In line with the SEEA EEA, degradation was defined as "a decline in the state and a decline in the flow of services". Finally, "on the whole, the types of accounts described in the SEEA EEA technical guide were deemed appropriate". Jean-Louis Weber seems to be the only expert to have mentioned the cost of restoration at the forum, apparently without much success. We also note that the correlation or causality between the Ecosystem services and the state of the ecosystem (or biodiversity) was not discussed because the working groups were divided according to the "cascade" model model (Haines-Young and Potschin, 2010)which separates ecosystems, functions (or capacities),

¹⁰² An analysis of the citations of Bartelmus' paper given by Google Scholar shows that these authors have never cited it (one article by Hein cites it, but for a secondary argument in Bartelmus' article).

the services themselves (flows) and the benefits derived. None of them worked on the whole chain, as their aim was to specify each link.

At the 21^e LG (November 2015), discussions were held on the definition of natural capital (Anton Steurer, Eurostat, and Aldo Femia, ISTAT) and the link between accounting and decision-making (Micheal Vardon, WB). Several papers based on experience were presented on values (Giles Atkinson, WB), biodiversity accounting (Micheal Vardon, WB), ecosystem capacity (Lars Hein, Wageningen University), ecosystem services and links with the SNA.

During the 22^e LG, the members had a more philosophical discussion than usual on monetary valuation. However, the general mood of the SEEA community prevailed. Aldo Femia discussed other economic frameworks for monetary valuation, but in the minutes we read that "The LG took note of this presentation. [...] We welcome the broadening of our knowledge base". The debate was certainly one-sided.

In the meantime, the UNSD has carried out a consultation to finalise the technical recommendations. It received 32 contributions and around 100 pages of responses. There was general agreement on the document. However, the following comments should be noted: "Clarify the discussion on the use of restoration cost approaches", "Elaborate and clarify the relevance of individual valuation methods" and "Explain the requirements for the use of modelled data in accounting" (UNCEE/12/6f). Overall, the comments were fairly positive at the time. They did not suggest the much stronger reaction that took place during the 2020 consultation on the economic valuation of future SEEA ecosystem accounts.

The meeting on 23^e LG provided an opportunity to prepare the ground for the review. Members discussed a number of issues relating to the research agenda. A long session was devoted to evaluation, with presentations from the UK. A brief reminder of the controversy between observation and modelling: it was said that a "big number" reflecting the value of nature was of little interest if it was not projected, based on forecasts of future flows of Ecosystem services. Some members expressed concern that it was not within the remit of national statistical offices to make such projections.

5.3.2.A smooth overhaul (2018-2020)

The review was launched at the first expert meeting in April 2018. Only approaches to revealing the value of nature were discussed, with the exception of two presentations (by Yann Kervinio and Hans Dieferbacher). Net present value and the cost-based approach were also the subject of two parallel sessions, but no report is available.

An expert meeting in May 2018 on monetary valuation will lay the foundations for the revision of the SEEA EEA on the subject. The main line of work is to seek consistency with the concept of exchange value or transaction price in the SNA. This will then make it possible to evaluate the wealth, degradation and enhancement of "ecosystem assets". A problem identified by Obst (2018) is the lack of dialogue between national accountants, experts working on valuation within the SEEA and those working on wealth (and welfare; in particular WB economists) accounting. The whole aim of the symposium is to clarify and articulate the points of view, and to see what comes under national accounting. The question then concerns the list of methods consistent with exchange value that can be included. In particular, we need to exclude anything that relates to well-being (stated preference methods, in particular, include consumer surplus, and therefore refer to well-being).

In his introduction, Obst describes "*cost-based approaches*". As mentioned above, these are not the 1993 framework, but valuation methods that include the term "cost". He points out that these are

attractive to national accountants, but less so to economists. Be that as it may, the question relates exclusively to the costs of producing or securing services. No link is made with the more general state of ecosystems. Moreover, the discussion concludes that these methods say little about the value of services (Harris, 2018). At best, they can provide information about bundles of services and could potentially serve as a proxy for replacement costs (which are normally costs to obtain a similar benefit by another means) (ib.).

At the expert forum in June 2018, a question was added: how to define the capacity of ecosystems to provide services? It seems important to clarify this intermediate notion between the state of the ecosystem in the broad sense and the benefits derived. In addition, the connection with the restoration costs actually spent appears in an introductory presentation by Rocky Harris.

Ole G. Pedersen (2018) provides a reminder of the place of modelling in National accounting. Of the nearly 70 presentations and sessions that took place, he was probably the only one to fully address this topic from a National accounting perspective. He explained that we should forget the idea of calculating a single value for ecosystems, because several underlying methods will necessarily be used. Furthermore, he again ruled out any possibility of calculating a green GDP, as this would require aggregating different conceptions of value. On the other hand, if the figures are presented in different tables and clearly articulated, there is no problem in presenting them in a single set of accounts. Since there is always a green GDP in the SEEA EA, why has this advice not been followed? Was it because it was still too attractive, or because there was no alternative? The second option seems to have taken precedence, as the experts wanted to get as close as possible to the constraints of the NA. Moreover, Obst told us that he had "spent an inordinate amount of time explaining that trying to adjust GDP was not the absolute goal. It is of course possible, conceptually, but we wanted to concentrate on the extent, the state and the flows of services. The idea was really to try to reduce the importance of GDP" (Obst, pers. comm., 10/05/2021).

This forum was an opportunity to validate the research questions and to really launch the working groups responsible for resolving the methodological issues. The UNCEEAA approved the organisation and research agendas. The only point of clarification made was to leave out anything to do with welfare measures. It would be possible to describe them in an appendix, but certainly not in the body of the chapters (UNCEEAA/13/minutes). The conceptual aspects were not discussed at the next LG (on 24th, in October 2018) or at the expert meeting in January 2019. Only what fell under individual Ecosystem services is included.

As the working groups had made good progress, it was possible to present a first draft of discussion papers at the expert forum in June 2019 (Barton et al., 2019; Fenichel and Obst, 2019; Obst and Edens, 2019; NPV et al., 2019). They are very rich and it is not possible in this chapter to make a summary that does them justice. The first in particular (Barton et al., 2019) places the concept of exchange value within a broader set of values and decision tools. These discussion papers have greatly clarified the exchanges between economists, statisticians and national accountants and clarified underlying issues that were previously unclear: the question of institutional contexts, values quantified by biophysical indicators, the need to clarify the notion of ownership and accounting boundaries (production and asset boundaries). One point that does not seem to have made much progress, however, since it is mentioned in the challenges to be met, is the list of valuation methods compatible with national accounts. The tension arises from the fact that almost all the proposed methods are not linked to the observation of real transactions (FE/2019/minutes).

Progress between June 2019 and the end of 2020 is presented on the LG 26^e (LG/26/minutes). Despite the "significant progress" indicated by Anton Steurer (Eurostat), the list of issues still to be resolved shows that the problems of the 1990s are still resurfacing: the connection with the exchange value of national accounts, and the role of the various institutions in compiling such information systems in the light of their constraints. In particular, statistical offices still cannot afford to make the assumptions necessary to produce such monetary valuations, especially as the quality of the data is not yet up to scratch.

At this symposium, Aldo Femia (Italian statistical office) presented a critique of the monetary approach used in the ecosystem accounts. The main criticism was that the imputations (modelling) were far too high. It also revealed the idea that the evaluation is ideologically oriented and that it is linked to a weak vision of sustainability. However, this criticism came late in the process, and many of those present did not wish to follow it towards abandoning any monetary approach (LG/26/minutes).

5.3.3. Partial freeze on money market accounts (mid-2020 to March 2021)

During the first round of consultation on groups of draft chapters, mixed and critical comments on the monetary accounts emerged. A small number of willing external reviewers (Statistics Sweden, Statistics Italy, the US *Bureau of Economic Analysis*, Walter Radermacher, the Chair of Ecological Accounting, for example) expressed reservations about the feasibility of monetary valuation (lack of data), its problematic motivations (instrumental vision and search for a "silver bullet" figure), and consistency with the SNA (too many assumptions needed and different concept of value).

This led to a number of changes to improve the quality of the manual, but without any radical changes to the general accounting approach (which was expected at this stage of the revision). A chapter entitled "Complementary approaches to valuation" was added. It describes the links with welfare values, details the valuation method for cost-based approaches, and recalls some elements of green economy modelling from previous SEEA publications.

Complicated negotiations ensued over what to do with the various chapters, given their relative robustness and the consensus surrounding each. Physical accounts for ecosystems and Ecosystem services were widely accepted and there was no opposition to their inclusion in the standard. Discussions centred first on whether or not to include monetary accounts in the main publication, and then on their status within it. The participating countries and international institutions also discussed whether or not to remove the word "experimental" from the title of the publication.

Australia, the United Kingdom, the Netherlands and the World Bank, among others, were in favour of including monetary accounts in the standard. Countries such as Germany, Italy, France and Sweden, as well as the United States, were opposed. The European Union, after discussions between member countries and through Denmark, finally supported the partition that was retained by the UNSC: the SEEA EA will contain seven chapters on the biophysical accounts of ecosystems, which constitute the accounting standard itself. These are the subject of a broad consensus and represent a step forward. The volume will also contain "internationally accepted statistical principles and recommendations" on ecosystem monetary valuation accounts, which are more problematic. This compromise makes the published manual rather ambiguous, even if the status of the various chapters is clarified in the introduction.

6. Discussion

6.1. A few thoughts on the process

Finally, we can identify a number of general trends concerning the people involved (from what country? From what type of intellectual/professional community?), the way in which the work was organised and what the main inflections were.

Firstly, it should be noted that the choice of 'wealth conventions' here is based exclusively on experts, with an extremely low level of participation from civil society (Jany-Catrice and Pinaud, 2017). This is not completely surprising on an international scale. But it does mean that any openness to societal considerations is only possible through the intermediary of the experts present. It is therefore their own sensitivity to the zeitgeist that infuses the SEEA with these kinds of considerations.

We can see that the roots of the SEEA lie in the limits of GDP. Their formulation in the 1970s led economists to make accounting proposals until the early 1990s. From then on, National accounting took up the subject again, while remaining linked to previous proposals. From 2000, and especially 2005, the growing involvement of the United Nations represented a significant change in governance. The experts retained their leading role, but lost a number of prerogatives. At the same time, these experts have changed. Traditional national accounting experts, increasingly hard to find, were replaced by statisticians.

Since the introduction of post-2003 governance, discussions have been calmer. As one expert put it:

"In the 90s, I attended LG meetings where people left the room because the discussion was totally unacceptable to them. The meeting at Fontevraud, in France, in a very beautiful monastery, was really terrible... Then, after 2012, the Australians presented their work. There was almost no resistance to accepting this line of thinking. It was surprising to see how fluid the discussion on the same subjects was." (anonymous, pers. comm., 2021)

On the other hand, the process increasingly relied on a perceived mainstream. When secondary voices began to lose the majority, some found themselves (or were) marginalised. This was to the benefit of the progress of the process and the meeting of deadlines. In this respect, the process was partly political and not purely scientific: despite the quality of the discussions that prevailed, decisions and action sometimes took precedence over the debate on ideas.

In the absence of expertise on ecosystems, the last period of the SEEA saw the community open up to researchers (not just economists) and more widely to 'experts' and consultants. This allowed a wider range of viewpoints to be expressed. The association of scientists after 2013 then tinged the process with an academic mindset. The appearance of scientific references throughout the SEEA EA is a sign of this, but at a deeper level, it is in the support given to particular approaches that we must look for the real change: the debate on modelling has taken a back seat, while monetary valuation methods have diversified. National accounting has been able to enter into dialogue with more diverse frameworks and disciplines (diversity of values and decision-making contexts; more in-depth discussions with officials in public policy design and evaluation departments, with economists, etc.). In addition, the large community of researchers working on 'Ecosystem services' has enabled this concept to become firmly rooted in the SEEA.

As far as countries are concerned, it can be said that the SEEA was mainly built by and for developed countries. This can be related to the need for a certain level of state control over the economy for the

System of national accounts to be useful, and for the state to have the capacity to invest in a developed statistical system. But this aspect was counterbalanced by the many programmes run by the World Bank in the countries of the South, to help them experiment and build capacity in this area.

The first discussions organised in the 1980s took place in Geneva, Washington and Paris. The London Group began with Canada, the Netherlands, the United Kingdom, Germany, Japan, Sweden, France and Norway as the leading countries. As we have seen, the United States played a relatively secondary role compared with its usual presence in international processes. From the outset, the UN and Eurostat have played a leading role, accompanied by the OECD and the World Bank. The Scandinavian countries have a very high historical participation rate, but they have mainly worked on the central framework, remaining (very) discreet about ecosystems and monetary valuation. Japan disappeared shortly after the 2003 publication. During the second period, the driving force of Canada and Germany steadily diminished in favour of Australia (and more secondarily the Netherlands). This is particularly visible for the monetary accounts, but less so for the rest. The World Bank has become a more important player, particularly with regard to monetary valuation, which has enabled it to establish its point of view in the long term. It left the community and active development of the methodology in 2012. During this second period, developing countries became more involved. While separate projects were devoted to them in the 1990s, they were more present in the process. But they remained secondary players. In the last period, from 2012 onwards, it is the Australians and the Dutch who are leading the work on monetary valuation.

Initially a discussion forum, governance of the SEEA was structured around the UN. While the UN has always been present (it launched the process with its first publication), the roots of a formal organisation around it emerged with the publication of the 2003 version. This began around 1997/8. It really became clear in 2004, when the UNCEEA began to be created. Since then, governance has become increasingly complex and differentiated. Whereas the London Group was a forum for in-depth technical and theoretical discussions in the 1990s, it now seems to be a kind of antechamber for statisticians tackling environmental issues. Most of the substantive discussions took place elsewhere during the last revision. Expert forums, Technical committees and meetings linked to related projects (ANCA, NCAVES, etc.) flourished. The governance of the revision of the SEEA EEA comprised five hierarchical levels (UNSC, UNCEEA, Technical committees, working groups, authors of *discussion papers*), compared with two in 1993 (UNSC, London group).

The creation of the UNCEEA had major implications for the way the controversies unfolded. Until 2005, on the whole, everyone (including the UN experts) was on the same level within the London Group. They were regarded as experts in environmental accounting and their proposals and arguments were treated on an equal footing. When the UNCEEA was created, the people involved became, more or less explicitly, managers, but also arbitrators, which did not exist in the initial London Group. The standardisation process became a means of reducing the importance of controversies between pairs (cf. Lemieux 2007, 207).

However, as the UNCEEA is made up of national accountants, its members retain a peer position. Furthermore, we are talking about an international process, which does not oblige national representatives. Thus, some controversies have ended (even after 2005): "rather [by] the exhaustion of the capacity of one of the camps to continue to defend itself publicly (for example, because of generational renewal)" (Lemieux, 2007, p. 208).

The factors that have influenced decisions are manifold, and their specific weight has evolved over time and according to the type of account. We can classify these factors in the following categories: technical arguments (feasibility, consistency with the SNA, availability of data, rational arguments, etc.), institutional considerations (institutional weight of countries and international organisations, governance), individual trajectory (career changes, retirement, personal skills/expertise).

This led to several inflexions in the accounting system: it became larger and more detailed, particularly on consensual issues such as physical accounts and defence spending. On the other hand, the cost-based methods and the GDP correction, which were initially fundamental principles, were diluted or disappeared for a time. Others have taken their place recently: biophysical measurement of ecosystems, Ecosystem services.

6.2. Conceptualisation of the economy-environment link and vision of sustainability

What does this story say about the conceptualisation of the economy-environment link?

One of the only moments when sustainability issues were addressed was in the introduction to the SEEA 2003, written by Anil Markyanda, who was commissioned for the occasion. However, in the eyes of some (Weber, pers. comm., 17/06/2020), it stands out from the rest of the document and is rather disconnected from it. The fact that Markyanda is outside the process certainly explains this. Interestingly, however, this is one of the few times that the SEEA has been discussed in the light of different conceptions of sustainability. The subject was then considered to be a matter for public policy and the uses of National accounting. It was therefore moved to the "Applications and Extensions" or similar volumes. But the type of sustainability (strong or weak) does not seem to have been discussed again.

However, in the light of the debates and technical choices made, we can propose an interpretation of certain trends. To do this, we propose to take several key design choices and see how close they are to a given conception of sustainability. Table 16 is the result of this analysis applied to the sequence of accounts based on the maintenance costs of the SEEA 1993 (United Nations, 1993a), Unpaid Ecological Costs (Vanoli, 2017) and the SEEA EA 2020 (Committee of Experts on SEEA ES, 2021).

The first choice concerns the unit of account. The choice of a single physical unit for natural capital is linked, at a very early stage, to the idea that capital substitution is neither possible nor desirable (this is the point of view adopted by Weber and Femia, for example). At the very least, it leads us to believe that it is, and does not allow us to *commensurate what is* environmental with what is financial or economic. It is impossible to carry out mathematical operations, and consequently to aggregate indicators from these different fields. No figure or indicator can therefore reflect the offsetting of one capital against another. In other words, no aggregate indicator will "hide" this possible compensation in a value that would remain the same.

Table 16 Orientations of three accounting proposals in relation to sustainability clusters

Methodological choices		Imputing unpaid costs (SEEA 1993, IV.2)	Ecological debt (Vanoli 2017; SEEA EA chap.12.3)	Revealing the value of nature (SEEA EA 2020)
Unit		€	Φ & €	Φ & €
Framework for monetary valuation	Focus on	Impact on the environment	Impact on the environment	Impact on the economy
	Definition of degradation	State of the environment	State of the environment	Loss of Ecosystem services
	Valuation method	Preservation costs	Preservation costs	NPV
Level of reality		Modelling++	Modelling++	Modelling++
Accounting structure	Aggregation	Yes (green GDP)	No (debt to nature)	Yes (green GDP)
	New institutional sector	No	"Nature"	"Ecosystem trustee"
	Main balance sheet account	Assets	Liabilities	Assets
	Integration	Satellite	"Partial integration"	Satellite

Legend: in grey, the choices tending towards weak sustainability, in green the choices linked to high sustainability.

Using a monetary unit to characterise natural capital makes it possible to compare the value of different capitals and make trade-offs accordingly. This is an essential step in constructing aggregate indicators. This is why this choice has often been equated with weak sustainability. In reality, making this choice within an accounting framework has different implications, invalidating this automatic conclusion (contrary to the claims of Dietz and Neumayer, 2007). In fact, the choices made regarding the other elements of accounting design are essential (and can act as safeguards), enabling a strong vision of sustainability to be maintained despite the use of monetary indicators in addition to biophysical indicators (the latter remain essential for correctly characterising the environment).

Thus, the monetary valuation framework has a very strong impact. It comprises several elements:

- What is being measured (the pressures on the environment or the gains and losses on the economy), and therefore, in a nutshell, the vision of the world (instrumental or not),
- The definition of degradation: is it linked to the state of ecosystems, or only to their capacity to produce services?
- Possible valuation methods.

The cost-based approach, defined in the SEEA 2003, whose valuation method is based schematically on the costs of achieving a desirable ecological state, assumes that the aim is to maintain intact or restore the integrity of the various environmental entities, defined for themselves. The choice of state (stock) indicators to define the environment makes it possible to base a monetary valuation on a strong sustainability approach. This is because, in order not to substitute natural capital, the values associated with it must first be based on a definition that reflects what it actually is! Otherwise, the monetary value is linked to something else. The damage approach, in this way, involves calculation methods linked to the gain or loss of services rendered by nature. In this way, it is not the environmental entities themselves that are the focus of attention, but the services they render to society. With this approach, we move away from the biophysical underpinning. The discussion that took place at the SEEA on the link between the state of ecosystems and their capacity to provide services is an excellent marker of

this shift. Although sometimes correlated, these two aspects are no less distinct. Thus, if we retain a definition of 'natural capital' as a set of environmental entities that we wish to conserve, relying on a definition of the thing itself, and not on uncertain proxies, is the only way of hoping not to substitute it with something else. The definition of degradation naturally leads to categories of monetary valuation: preservation costs or the Net present value of services.

In a similar way, modelling rather than observation is a risk we take in relation to decision-making and action, because we base them on a representation that is far removed from reality. We therefore consider that this choice leads us closer to weak sustainability.

In the structure of the accounts, aggregation naturally leads to masking the evolution of sub-components. For example, green GDP approaches, because they combine production and changes in the state of natural entities in a single figure, are linked to weak sustainability. In contrast, Vanoli's UECs are debts, which are disaggregated and must be repaid individually¹⁰³.

The creation of an institutional sector dedicated to the environment is an element that reinforces the exteriority of natural entities in relation to the economy. From this point of view, it brings the accounting system closer to the principles of strong sustainability, which recognises that they exist in their own right and are not necessarily instrumental. Furthermore, if this sector brings together not only natural entities, but also their representatives, it is because it is a question of representing actors who can speak in favour of natural entities, defend them, and in so doing avoid substitution by other types of capital.

In this respect, because each debt must be repaid individually, it is considered that the principal entry of the environment on the liabilities side is a guarantee that capital will not be substituted for other capital. Furthermore, the notion of debt is ontologically linked to non-substitutability (a provider of financing will certainly not be satisfied with an over-repayment made to another player). On the contrary, considering the environment as a value-producing asset in no way guarantees that this flow of value will not be replaced by another productive underlying asset from which we can derive the same benefit. Assets are the sole domain of the company. It acquires them and disposes of them as it sees fit.

Finally, the level of integration of accounts is double-edged, as was the use of monetary units. On the other hand, we believe that a high level of integration of information systems will enable better dialogue by creating a common language between the issues at stake. Including the environment in the representation of the economy (which makes it possible, in particular, to analyse income flows) enables discussions on the resources to be allocated to conservation. On the contrary, too great a disconnection, as we are seeing today, leads to environmental issues remaining invisible, at the risk of natural capital being subsumed by others, without even asking the question or realising it.

A comparison of the columns relating to the two versions of the SESA shows that it is possible to make quite different choices while retaining identical framing elements: both consider the environment first and foremost as an asset, but differ in the method of monetary valuation. Vanoli's approach, on the other hand, is less ambiguous and more coherent in terms of his conception of sustainability.

The general observation, with regard to the choices made within the SESA, is that the 1993 approach inherited numerous frameworks linked to weak sustainability, provided by economists who had worked on the subject in the 1980s. However, the national accountants of continental Europe

¹⁰³ Final consumption, to which Vanoli proposes adding UECs by imputation, is not the key indicator (unlike GDP corrected by the ESEA), but merely a means of balancing the accounts.

(Germany, Austria, the Netherlands and France) focused their attention on a framework for monetary valuation linked to strong sustainability in the 1990s. Once the research agenda on the subject was taken up by World Bank economists, the framework also followed the principles of weak sustainability. The Australians and Dutch, who have continued the work on ecosystems, have maintained and developed it to the current version of the ecosystem accounts. The result is a new version of the SEEA monetary accounts based almost entirely on the principles of weak sustainability.

7. Conclusion: positioning in these controversial areas

A detailed study of the monetary valuation controversy will give us a clearer idea of the position to adopt. More broadly, in the light of the rest of this thesis, it is possible to envisage ways out of these controversies. Generally speaking, we adopt the main thrust of Vanoli's scientific positions, while taking certain liberties.

The question of the unit of account seems to be based on the idea of complementarity of approaches. Biophysical units can be used to characterise conservation or restoration issues relating to natural entities, while monetary valuations can be used to produce quantifications that trigger action. The approach proposed here takes account of the incommensurability of ecological values, since we are not in any way seeking to quantify them. It is simply a question of translating into monetary terms the exchanges and relationships we have with ecosystems (in this case degradation or restoration) in the form of debts or claims.

The debate on the degree of reality of quantifications (modelling or observation) has finally found no resolution to date. Only Bartelmus (2014) suggests that it is through adapted business accounting that we could escape strong assumptions. This is also what the previous chapters suggest: since French National accounting makes extensive use of business accounting, it seems natural to do the same for the environment. It seems to us that this approach is a solution to the controversy surrounding the realism of environmental objects in National accounting.

Compared to Vanoli's approach, this implies substantial changes to the accounting structure, which we will retain. While the idea of debt seems appropriate, the idea of costs charged to consumption to explain their appearance seems more difficult to defend. These costs are virtual, in the very words of Vanoli (2017). We therefore prefer to use the account structure of the CARE model, which is perfectly consistent with that of historical cost accounting. The creation of new assets in return seems to us to be more easily acceptable since it is the treatment that is usually given when external capital is brought in. All the same, this raises the question of the definition of such assets, which is not at all obvious a priori.

The definition of a green GDP has been rejected on several occasions by advocates of strong sustainability (Dietz and Neumayer, 2007) but also by more traditional economists (Stiglitz et al., 2009b). We are perfectly happy to follow these economists on this point. That said, the CARE model proposes to make a clear distinction between what comes under exploitation (production) and what comes under preservation (repayment of the capital provided). It therefore seems necessary to raise the question of the individualisation of expenditure actually incurred for the environment from the rest of traditional production, and therefore, possibly, from GDP. This may seem close to the idea of defensive spending put forward by Daly and Leipert (Ahmad et al., 1989). We shall have to clarify this in the following chapters.

Finally, the last important conceptual choice, which is certainly the most difficult, is the framing of monetary valuation (by 'costs' or by 'damage', i.e. based on impacts or on Ecosystem services). Our analysis of thirty years of debate on this issue leads us to believe that it is inevitably political. It seems that the "accounting constraint" forces us to choose one or other of the two frameworks, because the monetary values of the environment must be consistent. The way we propose to record values calls for a single type of monetary valuation (the SEEA, in its own way, also imposes a single approach). But this accounting constraint does not provide any guidance for making the choice of framing. We would therefore have to rely on what the SEEA has deliberately excluded (LG/11/3a): schools of thought, epistemological or ethical anchors. For calm discussions to take place, it would be necessary at the very least to be able to explain these different anchors and compare them, rather than rejecting their study en bloc and allowing power struggles to prevail in negotiations on this subject. We could use the categories proposed by Desrosières (engineer, liberal, welfare, Keynesian and neo-liberal states), which are perhaps more concrete than the corresponding economic theories. But even the latter should be discussed jointly, on the basis of the clarification of their presuppositions, axioms and main propositions.

Making explicit choices in this area means accepting a certain relationship with the living world. It can be instrumental or relational, and follow the principles of weak or strong sustainability. Because it seems to us to be much better suited to negotiations in favour of preserving ecosystems and the environment, the monetary valuation framework that we have chosen is that linked to the principles of strong sustainability, i.e. based on the costs associated with an ecological objective. More generally, what is the basis for justifying this choice and attempting to move this controversy forward?

To do this, we suggest using the proposals by Radermacher and Schoer (Federal Statistical Office Germany, 2005) but also on the first chapter of this thesis. Both suggest that the needs of the main users of accounting should be taken into account when choosing accounting conventions. The objectives, modes of action and relationships that governments have with their economies today provide many clues as to the framework to be adopted. The issue of biodiversity was dominated by an instrumental vision in the international agenda of the 2000s (Millennium Ecosystem Assessment, 2003; TEEB, 2010; World Bank, 2006). However, over the last ten years or so, there has been a movement in the opposite direction, favouring the adoption of a strong sustainability framework. The IPBES is moving away from the canonical approach of Ecosystem services to talk about the contributions of nature to people, and recommends taking into account a plurality of values (IPBES, 2022). States are also increasingly adopting neutrality objectives, such as carbon neutrality, no net loss of biodiversity, good ecological status, no net land-take, and the European Green Pact. Their environmental ambitions are clearly higher than they were ten or twenty years ago. We are no longer creating pleas based on the supposed total value of ecosystems (Levrel and Missemer, 2020).

In order to choose a framework on an even more solid basis, we need to go further and put the users of such accounting into context by answering certain key questions: is monetary valuation a social process or a process of revealing value? (Godard and Laurans, 2008; Mermet et al., 2014)? ? What is the maturity of the environmental issue in question? (Feger et al., 2017; Latour, 2008)? ? What strategic context do producers and users find themselves in ¹⁰⁴(Mermet, 2011)? ? What are the real possibilities for action (negotiation, coordination, regulation, taxation, markets; what is the available budget)? The general discussion in this thesis will attempt to provide some answers. But we also see

¹⁰⁴ For example: what legitimacy and power does the government really have to manage this environmental issue? What is the position of the environmental stakeholder in the inter-ministerial and sectoral balance of power? Is the environmental issue conflictual or not?

this as an invitation to deepen accounting research by basing it on other types of analysis that have been little used until now.

Part 2- Developing a system of accounts

Chapter 4- Structuring ecosystem accounts to assess ecological debt in monetary terms

Disclaimer: this chapter is based on the following article:

Kervinio, Y. & Surun, C., Comte, A., Levrel, H., 2023. Defining ecological liabilities and structuring ecosystem accounts to support the transition to sustainable societies. OE 8, e98100. <https://doi.org/10.3897/oneeco.8.e98100>

The text of the article has not been changed, with three exceptions:

- French corrections have been made following automatic translation by the DeepL software.
- Figure 34 has been adjusted to correspond to the accounting structure described in this thesis, which differs slightly from that in the article.
- Additional parts appear (parts 2.3 to 2.5). These are parts taken from an earlier version and slightly revised following their presentation at the 28^e meeting of the London Group (in Bonn from 26 to 29 September 2022). These parts are still being researched and are not as complete as the rest of the chapter.

The summary provided for the 28^e London group also appears, in addition to the academic summary of the article.

Academic summary

To obtain reliable and relevant information on ecosystems, it is necessary to concentrate and prioritise the acquisition of information on aspects of interest. As a boundary object between ecosystem monitoring, research and public decision-making, ecosystem accounting can serve this purpose. We develop an argument for a set of accounts, consistent with the statistical standard part of the System of Environmental and Economic Accounting (SEEA-EA) that explicitly links monetary accounts to ecosystem extent and condition accounts. The ecosystem condition account is structured in three categories reflecting the main values motivating the objectives of integrated ecosystem management and the notions of "good ecological status". These categories are (i) the maintenance of their heritage dimensions, (ii) their capacity to provide ecosystem services sustainably and (iii) the maintenance of their overall functionality. We discuss how these ecosystem accounts and the associated monitoring system can form the basis for assessing an ecological debt using a cost-based approach, but also for designing an action-oriented information system that contributes to the transition towards sustainable societies.

Key words: ecosystem accounting, state of ecosystems, ecological debt, monetary valuation, cost-based approach.

Summary for the meeting of 28^e London group

Main problems identified:

1. The SEEA FC focuses on pressures (chemical-physical) and little on the services provided by the environment, whereas the SEEA EA does the opposite, but on different aspects (biotic issues).
 - a. The monetary accounts of the SEEA EA are based solely on the benefits provided by ecosystems (simple materiality), and deal very little with the pressures on the environment (necessary to assess double materiality).
 - b. Monetary accounts do not represent all the dimensions of interest for environmental management. In particular, natural entities whose preservation is not linked to their use.
2. There is little connection (partial correlation) or even disconnection between the condition account and the monetary accounts.
3. The net present value approach models entire markets and is relatively complex because it combines different valuation methods.
4. Monetary accounts are linked to relatively restrictive uses (cost-benefit analysis and analysis of the state of ecosystems only) and provide little decision-making support in several existing normative frameworks (distance to planetary limits, pressure reduction, European directives, etc.).

Answers proposed in this document:

1. The ecological debt approach can be used to describe and monetise the pressures exerted on ecosystems.
 - a. It would institutionalise a different relationship with the environment, based on double materiality.
 - b. It allows the creation of monetary accounts linked to all the environmental entities that we wish to manage and preserve (in other words, they include non-use values).
2. The ecological debt approach provides a complete link between the state and the monetary accounts, while also allowing for the management of Ecosystem services (thought of a little differently).
3. We believe that ecological commitments could be credible complements to the current monetary approach. They are based on exchange value and are conceptually simpler. However, they raise similar implementation difficulties.
4. It is more directly linked to certain important existing public policies and to the achievement of collectively defined environmental objectives. In Europe in particular, existing institutions are designed in a very similar way to this accounting model (European directives, impact assessment, non-financial reporting by companies with double materiality).

Questions for the London group:

Do you agree with the questions raised?

Do you think the proposed responses are appropriate?

1. Introduction

The need to complement traditional economic indicators, such as Gross domestic product (GDP), the unemployment rate or public debt, with a list of indicators capable of capturing a longer-term and broader view of social progress is widely recognised as a key element in achieving sustainability¹⁰⁵. To meet this need, the System of Environmental and Economic Accounting (SEEA EA) Ecosystem Accounting Framework was adopted in March 2021 by the United Nations Statistical Commission (UNSC). Biophysical accounts as a statistical standard (chapters 1 to 7) and monetary accounts (chapters 8 to 11) as an international recommendation. This system is an integrated, spatialised framework for monitoring and reporting on the extent, state, services and assets of ecosystems. This new standard leaves considerable scope for regional and national statistical institutes to implement it. At European level, the harmonisation of methods within a reporting framework will be overseen by Eurostat.

Ecosystem accounts bring together multiple data within a structured framework and derive standardised tables and indicators (Figure 32**Erreur ! Source du renvoi introuvable.**). It is useful to distinguish between the accounts and the underlying integrated information system, as both can be useful in different ways. The information system needed to produce the accounts is spatialised and organised around basic spatial units (USBs) to which various pieces of information can be assigned. Using a set of categories and conventions¹⁰⁶, accounts for the extent, state, supply and use of Ecosystem services are derived from this spatial grid. They form a set of biophysical accounts that can be used to construct standardised indicators. These accounts, in turn, shape the information system by drawing attention to specific ecosystem characteristics.

As a boundary object¹⁰⁷ between ecosystem monitoring, research and public decision-making, this framework offers great potential for multiple uses. However, despite a variety of exploratory implementations for ecosystem accounting, the effectiveness of these approaches in improving decision-making remains unproven (Comte et al., 2022; IPBES, 2022; Razzaque et al., 2019). Their implementation requires the continuation of stimulating research on measurement and evaluation, linked more closely to discussions on the various types of value and on the actual uses and impacts of accounting (IPBES 2022, message B7).

¹⁰⁵ See, for example, IPBES (2019)message D10.

¹⁰⁶ Examples in the SEEA-EA include the delineation of "ecosystem assets" or "ecosystem accounting areas".

¹⁰⁷ "Boundary objects are objects that inhabit several communities of practice and satisfy the informational requirements of each of them. [These objects have different meanings in different social worlds, but their structure is sufficiently common to more than one world to make them recognisable, which constitutes a means of translation. The creation and management of boundary objects is a key process in the development and maintenance of coherence between intersecting communities". (Bowker and Star, 1999)

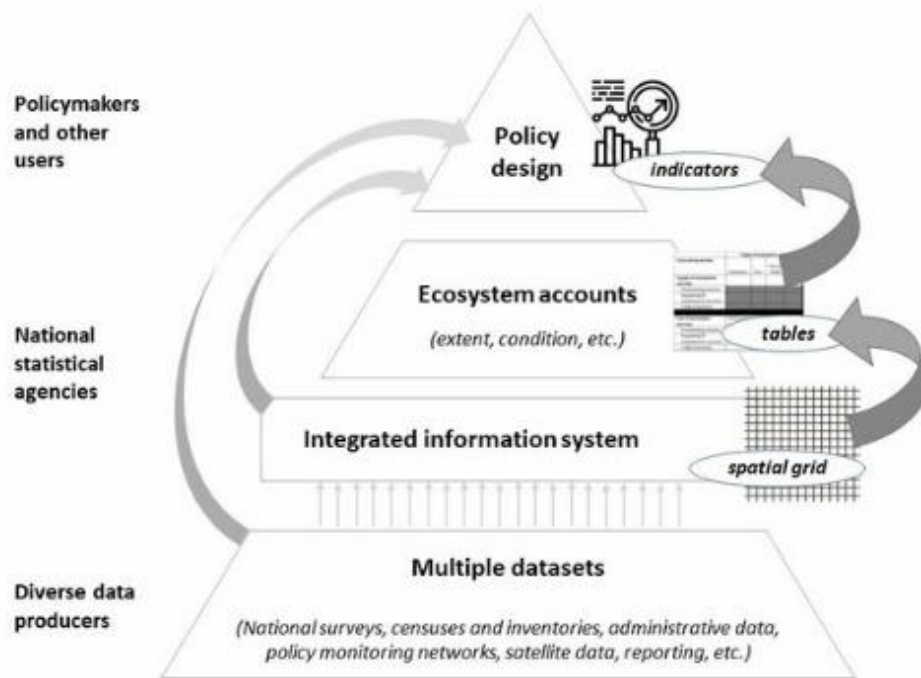


Figure 32 Ecosystem accounts as a boundary object between data producers and policy-makers.

Comment: policy-supporting indicators can be derived both from a structured accounting system where elements are progressively constructed through a set of rules and conventions driven by the conceptual framework (right arrows) or directly from the underlying information system (left arrows). From this perspective, the accounting system not only serves to produce indicators, but can also shape the nature information system by focusing on data gaps.

In this article, we propose responses to these challenges. We specify the characteristics of an ecosystem accounting system suitable for integrated ecosystem management and for monitoring ecosystem degradation at different scales. We highlight how estimating the costs required to achieve ecological objectives can lead to the production of useful information involving various types of value and communities. We also point out that certain features of this system (definitions, categories and valuation methods) depend crucially on the explicit identification of intended uses.

In the first section, we describe how ecological debts can be defined on the basis of commitments to maintain and restore ecosystems, and expressed in both biophysical and monetary terms. In the second section, we then examine how such an approach could be integrated into a dynamic socio-political process of defining and implementing environmental objectives. In the third section, we examine how the dimensions of interest and reference levels used in biophysical accounts could be derived from existing management objectives with various underlying rationales. In conclusion, we discuss the main avenues of research needed for such an accounting system to be used to a degree comparable to economic accounts and to provide substantial support for the transition to sustainable societies.

2. Valuing ecosystem degradation as an ecological debt

Among existing proposals to complement GDP, a monetary indicator of the costs of ecosystem degradation could provide a comparable measure of economic outcomes. First, we present and discuss

the conceptual framework of the cost-based approach to estimating such an indicator. We then examine practical options for its implementation.

2.1. Assessing the costs of ecosystem degradation - conceptual framework

Two distinct frameworks have been discussed over time in the SEEA manuals concerning the monetary valuation of the costs of ecosystem degradation (United Nations, 2021, 1993b; United Nations et al., 2003).

In the first framework, the focus is on the *costs borne by humans as a result of* environmental degradation, these costs being considered as damage or (*negative*) benefits. *Damage-based methods* (United Nations et al. 2003, chapters 9 and 10) and the current recommendations for the assessment of ecosystem degradation in the SEEA EA (United Nations 2021, chapter 10) are two approaches developed from this perspective, initially called "costs borne" (United Nations, 1993). The latter approach differs mainly from the former in that it moves away from the assessment of "well-being" towards "exchange" values based on losses of Ecosystem services. In the latter approach, ecosystem degradation and its costs are defined identically as the decline in the net present value of the expected future returns from the ecosystem services provided by the "ecosystem assets"¹⁰⁸.

In the second framework, the focus is on the *costs caused by (human-induced) environmental degradation*¹⁰⁹, where these costs are understood as the expenditure or effort required to avoid the degradation of ecosystems or to restore them. Approaches developed from this perspective originally referred to as "caused costs" are currently referred to as *restoration cost approaches*¹¹⁰ in the SEEA EA (United Nations 2021, §12.32). Examples are estimates resulting from green economy modelling (United Nations et al. 2003, §10.199, Hueting, 2013) or the "Unpaid Ecological Costs" proposed by Vanoli (1995). In all these approaches, ecosystem degradation remains defined in biophysical terms as the difference between the current state and a certain reference state, while its costs are the costs of

¹⁰⁸ In this article, we simply use the term "*ecosystem*" and not "*ecosystem asset*", because this term evokes a narrow notion of value, limiting total economic value to flows of ecosystem services, and the inclusion of ecosystems in the economy.

¹⁰⁹ We can note that, although the causal attribution of degradation to economic entities was central in the initial framework (costs were caused by economic entities), this attribution subsequently proved less important with the appearance of macro-aggregate proposals without explicit treatment of the cause of degradation. We therefore present this framework in a way that does not require such attribution.

¹¹⁰ We use the most recent designation here (United Nations 2021, §12.32-42), although it is interesting to comment on the gradual evolution of this term and the sources of confusion that arise from it. Starting from the initial - rather accounting - distinction between approaches based on costs borne and approaches based on costs caused, these frameworks for assessing ecosystem degradation were taken up again in the 2003 version according to the - more economic - distinction between approaches based on damage and approaches based on costs. Both approaches were then considered to focus on methods for assessing well-being values, which is not the case. The recent move away from welfare values leads to an explicit move away from damage-based methods (United Nations 2021, §12.6) while maintaining the main focus (on lost benefits). At the same time, the meaning of "cost-based approaches" has also changed. Following the presentation of a paper at the 2011 Expert Meeting on Ecosystem Accounting (Pittini, 2011) cost-based approaches are no longer contrasted with damage-based approaches as two different ways of conceiving the assessment of ecosystem degradation, but more broadly describe all assessment methods that use some notion of "cost" to assess either ecosystem degradation (maintenance costs, avoidance costs, restoration costs, abatement costs, etc.). What is even more confusing is that, when used to estimate Ecosystem services, "cost-based *methods*" can in fact be used within a "damage-based *framework*" to assess ecosystem degradation. This explains why "cost-based methods" should now be specified as "cost-based approaches to restoration (or maintenance)", rather than simply "cost-based approaches to ecosystem degradation".

measures needed to maintain or restore ecosystems from their current state to this reference state. The proposal examined in this document also follows this framework.

As we shall see in the second section, both valuation approaches can inform ecosystem management at different stages of the policy cycle. In short, estimates based on the first approach can be useful for justifying policies and actions, while estimates based on the second approach can be used to organise action to prevent or remedy ecosystem degradation (United Nations et al. 2003, §11.124).

However, we can highlight several major difficulties in using the first framework to assess the cost of ecosystem degradation at national level. The first difficulty relates to the indeterminacy of the preferences required to carry out such an assessment. Assessing future flows of Ecosystem services requires assumptions about the future state of ecosystems and the economy. The associated uncertainties also need to be quantified and assessed, in line with existing attitudes to risk and uncertainty. Finally, we need to be able to infer the fundamentally unknown preferences of future generations and include non-use values. All of these issues pose considerable conceptual and practical difficulties. For example, we can note that, despite their recognition, non-use values are currently excluded from the value of ecosystem assets in the SEEA EA (United Nations 2021; §6.72). It should also be emphasised that the values associated with ecosystems and biodiversity are not always pre-existing, but can emerge from individual reflection and public discussion. Valuation must therefore be seen in the context of socio-political value formation processes (Kenter et al., 2015; Sen, 1995; Spash and Hanley, 1995).

Another difficulty is linked to the different nature of what has value when faced with complexity and uncertainty. The SEEA EA approach to assessing ecosystem degradation is based on simple representations of local causality of the DPSIR type¹¹¹, going first from pressures to changes in state, then from changes in state to impacts on benefits. However, in complex systems, where non-linearity and uncertainty prevail, local causal chains can no longer be assumed (Chavalarias, 2020). One of the consequences of this situation is that objectives relating to pressures must be defined, as they cannot be deduced unambiguously from objectives relating to the state of ecosystems. This is what the French BA recognises, for example, when it recommends setting targets directly for agricultural practices. It justifies this on the grounds of the time lag and the many sources of variability between these practices and the eutrophication of ecosystems (Cour des Comptes, 2021). In these examples, we see how complexity leads to the recognition that pressure reductions have a value in their own right. Here, the value of a reduction in pressure cannot be estimated by a difference in damage, but by an implicit valuation approach, based on what is collectively valued, as revealed by the existing objectives.

A third difficulty relates to the different meanings of monetary values covered by existing valuation methods. In practice, Ecosystem services are valued using a variety of interrelated but distinct concepts (e.g. market price, opportunity cost, real cost and willingness-to-pay). This limits the ability to pool or add up the resulting figures, although many of these figures may be useful in different contexts. The impossibility of harmonising use and exchange values and the drastic reduction in the scope of valuation is a striking example of these concerns. Along these lines, Femia and Capriolo (2022) advocate that the numerous monetary values proposed should not be additive, but that they should all be useful distinct elements of an information system capable of responding to a diversity of political needs.

¹¹¹ The Driving Force-Pressure-State-Impact-Response (DPSIR) framework (European Environment Agency, 1999).

Most of these discussions are not new and we note that the London Group's research programme in the 1990s suggested studying the restoration cost approach (Bartelmus, 2014; Brouwer et al., 1999; Radermacher et al., 1999; United States Bureau of Economic Analysis, 1995). Among the most advanced proposals, André Vanoli has developed an argument in favour of a cost-based approach to measure, in exchange value, the costs of the observed degradation of ecosystems (Vanoli, 2017, 1995). From Vanoli's perspective, the 'Economy' would continue to have its own information system structured according to the SNA¹¹². A specific institutional sector called "Nature" would be considered as an entity distinct from the "Economy" and endowed with its own information system. The relationship between "Nature" and the "Economy" could be monitored according to the commitments that bind them. "Imputed ecological costs" can then be defined as *"[representing] the value, in terms of avoidance or restoration costs, of the degradation of ecosystem assets over a given period due to economic activities"* (Vanoli 2017). Unlike the imputed maintenance costs of the 1993 version of integrated environmental and economic accounting (United Nations 1993), these costs are considered a liability, i.e. a commitment to be paid in the future¹¹³. More recently, Germain and Lellouch (2020) have defined a "prospective debt" from an economic perspective as *"the discounted equivalent of the flow of future expenditure required to meet a given liability"*, thus defining *"a notion of implicit liability used for other types of public expenditure such as retirement pensions"*.

Based on these notions of *"unpaid ecological costs"*¹¹⁴ and *"prospective debt"*, we define a monetary ecological debt as the costs that would have to be incurred in order to reach certain reference levels on the dimensions of interest of *the* extent and state of ecosystems¹¹⁵. We now focus on the practical implementation of an aggregate measure of the costs of ecosystem degradation at the national scale, starting with a practical assessment of the costs required to achieve certain reference levels.

2.2.Valuation in practice - modelling or observation?

In the second framework (the costs caused), two distinct approaches are possible for the practical estimation of the cost of ecosystem degradation. We call them the *economic* perspective and the *accounting* perspective.

From an **economic perspective**, estimates are made using different types of model. Technical-economic models are the first type. They are based on a database of possible measures for achieving defined objectives, together with their costs and impacts. From this base, the estimate generally

¹¹² That it proposes renaming the System of National *Economic* Accounts (SNEA) instead of the SNA to clarify its scope, which is restricted to the economic sphere.

¹¹³ In this sense, ecological debt refers to the debt defined "prospectively" by Germain and Lellouch (2020).

¹¹⁴ We note at this point that our proposal differs from the initial proposal in several respects. In particular, from an accounting technical point of view, Vanoli (2017) proposes to increase Final consumption (and therefore savings) of institutional sectors with an impact on the environment in order to balance the accounts with the new debt. A different treatment of ecological debt could be envisaged, more in line with the CARE model (Rambaud and Richard, 2015). This would involve following a more traditional recording procedure, similar to that used for financial debt: an entry is made on the liabilities side and another, for an equal amount, is made on the assets side. This requires the creation of a specific category of natural assets, corresponding to the way in which the debts are used by the sectors. For example, for a climate debt, the corresponding asset is "CO storage₂". This approach guarantees the double entry and the balance of the accounts (Rambaud and Chenet, 2021). Although it is theoretically valid from an accounting point of view, its actual content and quantification still require further work.

¹¹⁵ We will concentrate on how to construct the biophysical information system and the physical and monetary debt accounts. We will not go into the accounting treatments in the sequence of accounts, which would merit a more in-depth discussion.

consists of adding the cost required to implement the measures, from the least costly to the most costly, until the reference level is reached¹¹⁶. Macroeconomic models are of a second type (Brouwer et al. 1999). They estimate the cost of achieving objectives directly, based on a representation of how financial efforts translate into impact (dose-response models).

The resulting estimates are uncertain, in particular due to limited knowledge of future market conditions and technical progress. Given the limitations and uncertainties associated with modelling, comparisons between model results or regular model updates are necessary to ensure reasonable estimates. For example, Germain and Lellouch (2020) assess what they call a "prospective debt" linked to climate change mitigation targets for France. They develop a simple macroeconomic model which, they show, gives results consistent with another pre-existing technico-economic model. They also show that the carbon value derived from their macroeconomic model is roughly consistent with the carbon trustee value used in France to evaluate public investment, which suggests that their estimates are reasonably robust. It should also be noted that the estimate of the latter carbon reference value is itself based on a comparison between the results of the technico-economic and macro-economic models (Bureau et al., 2021; Quinet et al., 2019).

For biodiversity and ecosystems, many models linking responses to outcomes on the dimensions of interest could be used to make similar estimates. For example, the scientific literature on wetland restoration costs can provide robust estimates of the budget needed to achieve specific ecological outcomes (Szałkiewicz et al., 2018). Recent reports also estimate how much it would cost to halt the erosion of species and natural habitats by 2030 (Deutz et al., 2020). However, greater complexity may result from the need to take account of the multiplicity of drivers of change (and their non-linear combination) and the multiplicity of dimensions of interest (and their interactions)¹¹⁷. In order to sketch out the contours of effective trajectories, as well as their overall costs, it will be necessary to integrate several models and carry out explicit spatial modelling. The resulting estimates will be subject to considerable uncertainty. So, as with the climate, credible values will require model intercomparisons and regular updates (Guivarch et al., 2017; Riahi et al., 2022).

The **accounting perspective** is very similar to that used today in national economic accounting. The national ecological debt indicator results from the aggregation of costs estimated and reported at the level of economic units (companies, Households, government, etc.). This approach requires the accounting of organisations (companies, administrations, etc.) to be extended in order to monitor impacts and responsibilities at this level. Some legal procedures, although still partial, already exist, for example through environmental impact assessments for development projects. Non-financial reporting is also becoming increasingly standardised, for example through initiatives such as the European Union Directive on Corporate Sustainability Reporting (CSRD).

More ambitiously, extended and standardised accounting models could ensure the production of appropriate information. The Comprehensive Accounting in Respect of Ecology (CARE) model is an

¹¹⁶ It should be noted that such a focus on (economically) efficient trajectories may be questionable due to non-market side effects, complex dynamic effects (lock-in, uncertainties, knowledge gaps, etc.) or difficult trade-offs. As a result, efficient trajectories derived from these models may not be socially desirable and the resulting estimate may indicate a lower bound on required costs. Its practical significance, as an indication of funding requirements for example, needs to be carefully considered.

¹¹⁷ This is all the more important as the advantage of certain measures, such as nature-based solutions, lies in their *multifunctionality*, i.e. their ability to solve multiple conservation and social problems simultaneously. Ignoring these synergies can lead to a systematic bias against such measures.

example of this type of model. Under this model, organisations would be required to monitor and report their impacts or pressures on ecosystems against ecological reference levels ¹¹⁸(Rambaud and Chenet, 2021; Rambaud and Richard, 2015). Within this framework, organisations declare as liabilities in their own accounts the cost of prevention and restoration measures required to ensure that these reference levels are achieved¹¹⁹. With an audit procedure similar to that for financial reports, reliable data would be produced. If the reference levels set at the level of the organisations are compatible, on a larger scale, with the environmental standards of the territories in which they operate, the bottom-up aggregation of responsibilities will provide an estimate of the costs of ecosystem degradation.

The economic and accounting perspectives both cover the investment and recurrent costs, in exchange value terms, of achieving existing objectives. However, they differ in the extent to which certain types of environmental action are taken into account. This reflects the differences in objectives and concerns between the economic and accounting disciplines. Whereas the accounting discipline seeks to assess reliable, tangible and enforceable payment obligations that are unambiguously attributed to an entity, the economic discipline seeks to assess values that are relevant to decision making, even if they are more hypothetical or not clearly attributed. Consequently, the extent and nature of the costs covered by the ecological debt indicator may differ between the two perspectives, leading to different interpretations and relevant uses. For example, with regard to the coverage of costs, only those linked to reduction and restoration measures are mobilised from the accounting perspective¹²⁰. On the other hand, the economic perspective adopts a broader scope, possibly including avoidance measures, quantifiable by the opportunity costs of foregone projects. In terms of the nature of the cost information covered, the economic perspective departs from the simple observation of actual transactions and other facts. It involves models, assumptions, normative inputs and requires interpretation (for example, comparisons between model results). Many authors have opposed these 'hard modelling' approaches in official statistics, as they are thought to undermine the accuracy and confidence in the information produced (Desrosières, 2009; Radermacher, 2020; Vanoli, 2017). Consequently, the economic perspective can be carried out outside official statistics, in a specific institutional context involving research and other public institutions in close coordination with official statistics. The accounting perspective, on the other hand, is based on the observation of approved accounting information. It is more in line with the traditional role of official statistics and National accounting.

Now that we have described how to quantify the degradation of ecosystems, let's see where to integrate these amounts into the sequence of national accounts.

¹¹⁸ These reference levels may - but need not - reflect actual legal obligations. They can be defined and allocated between economic units (companies, governments, etc.) in accordance with conventional reporting rules.

¹¹⁹ Our approach is only possible if there is at least one reasonable way of preventing (ex ante) or mitigating (ex post) the degradation of ecosystems. Otherwise, we are outside the scope of ecological responsibility accounting. The need to recognise that impacts are irreversible or that their cost is "disproportionate" would lead to the redefinition of new, more realistic objectives and related status indicators. This limitation can also be an asset from a practical point of view, as it makes it possible to identify realistic (and therefore more likely to be effectively implemented) actions for the sustainable management of ecosystems. Furthermore, it goes hand in hand with the need to define precautionary objectives in terms of pressures, particularly when faced with irreversible risks. We return to this point elsewhere in this article.

¹²⁰ In the CARE accounting model, preservation costs are expenses that do not alter an organisation's business model and whose primary function is to preserve the environment. They include reduction costs (prevention actions) and restoration costs (repair actions). Avoidance costs, on the other hand, relate to actions that modify the business model with the secondary objective of reducing environmental impact (e.g. electric cars). To avoid double counting and 'difficult modelling', they are not included in the calculation of ecological debt.

2.3. An extended account sequence including ecological liabilities and assets

We note that our proposal differs from Vanoli's work on several points. In particular, regarding the accounting structure, Vanoli (2017) proposed to increase Final consumption (and therefore savings) of institutional sectors that have had an impact on the environment in order to balance the accounts with the new debt. We consider a different treatment, more in line with the CARE model (Rambaud and Richard 2015). It follows a more conventional recording, similar to what is done for a financial debt: one entry is made on the liabilities side, and another, for an equal amount, is made on the assets side. This requires the creation of a special category of natural assets, which correspond to the way in which the debts are used by the sectors. For example, for a climate debt, the corresponding asset is "CO storage₂" (Rambaud and Chenet 2021). This approach also ensures that the accounts are double-entry and balanced. Although theoretically valid from an accounting point of view, its actual content and quantification still require further work.

Thus, we see an important distinction with the SEEA EA. As mentioned above, we do not consider ecosystems as assets. Ecosystems are natural entities external to the economy, which are not, ontologically and *a priori*, appropriable objects that are sources of value. Our approach allows us to recognise their duality as an entity to be preserved and a real source of value. It is only when an ecosystem is actually used by an economic unit that accounting records a new transaction, by entering values on the assets and liabilities side of the balance sheet.

We now turn to a more detailed discussion in order to clarify the definition of ecological assets from an accounting point of view.

2.4. Define assets as uses of environmental liabilities

2.4.1. Method and theoretical conception

The theoretical conception of assets under historical cost accounting (with which the CARE model is consistent) is a subset of what is included in the definition of the SNA, so there is no *a priori* risk in going outside this framework. Indeed, we saw in Chapter 2 that historical cost adds the requirement of a sacrifice on a resource in addition to what is specified in the SNA. To design a typology of natural assets, we therefore need to look for candidates that are compatible with the following two definitions:

"An asset is a store of value representing a benefit or series of benefits that the **economic owner** derives from holding or using an asset for a specific period. It is a **means of transferring value from one accounting period to another**." (United Nations et al., 2011, para. 3.30./10.8.)

"An asset is a degraded use of capital¹²¹ that is not yet useful for value creation" (source: author, based on. Rambaud and Chenet, 2021; Rambaud and Feger, 2019).

The notions of resource and (economic) ownership must be present, as well as the idea of reserve or use not yet useful (as opposed to direct consumption). The CARE model also requires the idea of sacrifice.

¹²¹ Thereafter, the term capital refers to liabilities rather than assets (Rambaud and Chenet, 2021; Rambaud and Feger, 2019).

Since an asset is both a source of value and a source of capital degradation, we will try to see how these two notions come together and when they overlap. This will guide us towards the identification of natural assets. Ecosystem services are precisely the way in which the notion of benefit, of value derived from ecosystems, is now commonly understood. It is therefore an essential starting point. In addition, environmental degradation is regularly studied in public policies (particularly European directives) to estimate the efforts to be made and the actions to be taken to halt the loss of biodiversity. They are a good starting point for integrating the dimension of capital degradation.

In the SEEA-EA, Ecosystem services are defined as follows:

"6.9 [...] Ecosystem services are the contributions of ecosystems to benefits that are used in economic and other human activities. In this definition, use includes direct physical consumption, liability enjoyment and indirect reception of services. In addition, Ecosystem services encompass all forms of interaction between ecosystems and people, including both in situ and remote interactions. (translated from: Committee of Experts on SEEA EEA, 2021)

The service typology distinguishes three categories:

- "6.51 [...] Provisioning services are ecosystem services representing contributions to the benefits that are extracted or harvested from ecosystems.
- Regulation and maintenance services are the Ecosystem services resulting from the capacity of ecosystems to regulate biological processes and influence the hydrological and biochemical cycles of the climate, and therefore to maintain environmental conditions that are beneficial to people and society.
- Cultural services are experiential and intangible services linked to the perceived or real qualities of ecosystems, whose existence and functioning contribute to a range of cultural benefits. " (translated from: Committee of Experts on SEEA EEA, 2021)

If, on the basis of the underlying functionality of the ecosystem, Ecosystem services are compared with the pressures listed for reporting under the Habitats, Fauna and Flora Directive, we obtain the cross-tabulation shown in Table 17. It should be noted that the "benefits" that can be derived from certain pressures are far from intuitive. For example, what is the benefit of pollution (e.g. CO₂ emissions)? The emission of CO₂ is in fact essential to the smooth running of most internal combustion engines: if it is not expelled from the engine after combustion, it will asphyxiate the engine by taking the place of the oxidant, O₂. So the benefit linked to this emission is the smooth running of the engine. To translate this, Rambaud and Chenet (2021) call the corresponding natural asset "CO₂ storage". This idea of storing pollutants can be extended to a number of emissions, such as discharges into the aquatic environment. The case of the destruction of individuals and land for economic activities is similar: the removal of living beings and the reworking of land frees up space and makes it usable as a physical support for the construction of human infrastructures. The other pressures must be subject to the same scrutiny in terms of their real usefulness for the economic model.

Table 17 Accounting uses at the intersection of Ecosystem services and environmental pressures

Ecosystem service	Benefit without degradation	Benefit with degradation	Irreversible or not related to an activity degradation	Pressure
Provisioning	X	X	X	Overexploitation
Regulation (pollution, nuisance, buffer spaces)	X	X	X	Pollution
Regulation (pollination)	X			
Cultural (recreation)	X	X	X	Disturbance
Cultural (other)	X			
		X	X	Injury
		X	X	Destruction of individuals
		X	X	Physical modification of the environment (drainage, settlement, coastal or hydrological modifications)
		X	X	Ground surface area
			X	Natural dynamics

Legend: The categories of Ecosystem services are those classically defined (EEA Expert Committee, 2021; Haines-Young and Potschin, 2012) which we have broken down for our analysis. The pressures are taken from a synthesis by the author based on the typology of pressures used for the 2013-2018 reporting exercise under the Habitat, Fauna and Flora Directive. Ecosystem services and pressures are compared when the ecosystem function underlying the service is the same as that overexploited by the pressure in question. Some cannot be (e.g. pollination), hence the absence of a corresponding pressure. Some pressures are not based on the functioning of an ecosystem (for example, the destruction of individuals). The crosses indicate the potential existence of a liability (green), employment (orange) or situations that fall outside the scope of ecological debt accounting (red).

A priori, there are several cases that should give rise to the recording of a natural asset (the last being debatable):

- The overexploited natural function is used intentionally (e.g. overexploitation of a biological resource, disturbance due to recreational use).
- The natural function that is overused is used involuntarily. Use is a secondary effect that the economic model cannot avoid in its current state (for example, unavoidable pollution such as CO₂ emissions from an internal combustion engine, disturbance caused by a road passing close to a natural area).
- The natural function that is over-exploited is not useful to the economic model. It might not be used if the economic model were more precautionary (e.g. nitrate leaching, accidental degradation). This case is more delicate because it has been specified in the definitions that a use must be useful to the business model. On the other hand, it can be argued that a wasted resource

remains an expense for the company, and that if the resource comes from a liability, its use does not change the amount that must be repaid.

The "profit with degradation" column can be assimilated to a use. They still need to be renamed to fully reflect both aspects in the usage name.

The site Figure 33 details the relationship that can exist between the use of Ecosystem services and the resulting degradation of the ecosystem. Some Ecosystem services can be used beyond a point that leads to degradation of the state of the ecosystem that provides them. This is the case for provisioning services and certain regulatory services (absorption of pollutants) and cultural services (recreation). When these services are overexploited (too much extraction, too much pollution, too much recreation, etc.), degrading use can occur. Before this point, the flow is purely positive for the economy: we benefit from Ecosystem services without impacting ecosystems. Once this threshold is reached, we come to the classic notion of degradation, which we find in the pressure typologies.

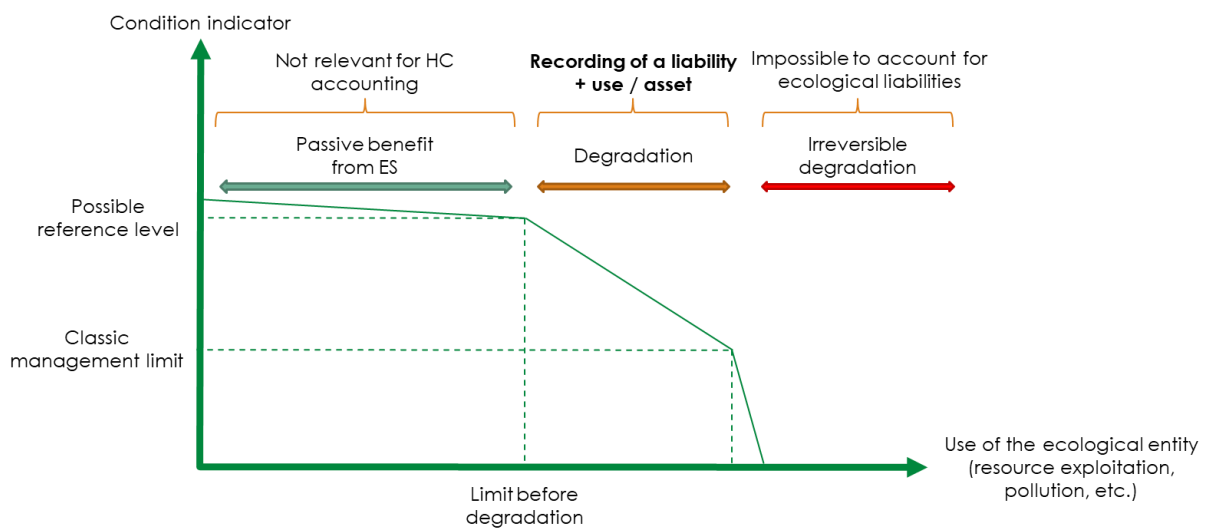


Figure 33 Stylized relationship between the state of an ecosystem and its use

This figure illustrates the boundary that could be drawn between the monetary accounts of the SEEA EA and the asset accounts that we are proposing. To avoid double counting, it would be necessary to stop recording benefits in the SEEA EA accounts as soon as a deterioration occurs with the use of the service. This would leave room for other natural asset accounts, linked to the ecological debt. The recording of these assets stops as soon as the degradation becomes irreversible. In fact, we are moving away from the ecological debt framework because there are no longer any means of assessing the costs of reduction or degradation in monetary terms, due to the lack of techniques for managing these impacts. We then fall into another management mode, that of regulation or fines.

The next step is to check that these uses, these potential assets can be acquired, owned economically (possibly legally). As far as the benefits corresponding to these potential assets are concerned, it would seem that it is the economic players who use the capital who benefit. The case of natural resources seems obvious, as we have seen with the examples of pollution and the destruction of ecosystems to build infrastructure. We can consider that the risks incurred are the obligation to repay the capital.

2.4.2. Quantification

Monetary valuation is a thorny issue in the transition to National accounting. CARE accounting recommends allocating the amount of the debt to the corresponding assets using a physical degradation factor (for example, in a very simple way: each type of land use receives a proportion of

the total monetary debt equal to the corresponding surface area). In this way, the different uses receive an appropriate proportion of the preservation costs. Can we consider that the values estimated in this way inherit the characteristics of the ecological debt, in particular its nature as an exchange value? Are the revaluation methods used to update the value of assets each year appropriate here?

The valuation of assets in the CARE model implies that the more they are used (the more the corresponding capital is degraded), the higher the asset figure. Thus, the amount entered in the asset increases with the degree to which natural capital is transformed for human use. And the amount decreases with more respectful use. This may seem counter-intuitive. In fact, we need to look at it in a broader context, and in particular with the idea of capital preservation: this definition of assets implies that "the greater the degradation they cause, the more 'difficult' it will be to maintain the capital and therefore the lower the benefit" (Rambaud, 2015, p. 384)..

We can also establish a link with the microeconomic theory of markets. If environmental debts are to be repaid over the long term, the companies that contract them have first carried out cost-benefit analyses to determine whether the use of this environmental capital should provide sufficient value within the current economic model to enable the production of a good or service that will cover the repayment of the capital. In other words, the value placed on the asset (in terms of preservation costs) must be less than the gains expected from its use, if the company has made its calculations correctly. The value of natural assets is therefore a minimum of the expected gains. The value of the asset that is actually recorded is therefore the company's marginal willingness to pay. Knowing that this amount will have to be paid in the future for the use of the asset, the company reacts to it in the same way as to a traditional market price.

Because of this time lag, we can still see that these values are close to the offer prices (van de Ven, 2022) For these reasons, "contracts provide for an offer period, sometimes several months after the property changes hands" (United Nations et al., 2011, paragraph 3.129). Thus, "an estimate of the market value at the time of transfer of ownership should be made. This estimate should be revised according to the actual market value, if known" (ib.). In fact, the CARE model also proposes such a revision to take account of changes in preservation costs that may occur over the period.

2.4.3. Provisional conclusion on the definition of assets

This account presents pressures in the same terms as the state of the environment indicators. Unlike Ecosystem services, which classify the benefits that can be derived actively or passively from ecosystems, the use account focuses on the active use that leads to ecosystem degradation. Thus, Ecosystem services only appear in the use account when their use degrades the ecosystem (exceeding the pollutant's absorption capacity, overexploitation of a supply service, pressures linked to recreational use, etc.). Other uses are also included: any degradation, intentional or not, linked to the function (production or consumption) of an institutional unit (Households, business, administration, etc.) is taken into account. Examples include the storage of pollutants (including greenhouse gases) in the environment, artificialisation, reduction in the population size of protected species, etc.

Compared with the SEEA EA, our approach presents several essential differences: ecosystems are not called assets, ecological assets are named differently and use a different typology, and the monetary valuation is different. However, this does not call into question the whole logic of the SEEA. Indeed, the overlap is limited to certain provisioning, regulating and recreational ES, and only once degradation actually occurs. It is possible to quantify the assets of the SEEA on the basis of the value of the ES that are provided without environmental degradation in a separate account of our "ecological assets". This requires abandoning the idea of a sacrifice necessary to obtain an asset. The two approaches are

therefore complementary. We therefore propose to leave the SNA definition of assets unchanged, as it encompasses CARE's concept of natural assets. It is broader, which leaves the door open to the SEEA EA definition of assets. We will therefore clearly delineate what separates the two, allowing us to design a system that hybridizes the two approaches.

2.5. New natural capital account among wealth accounts

We propose to include the ecological assets described above in a new account called the "natural capital account", with reference to the existing capital account (Table 18). The first half of this account would function like the capital account, recording Gross fixed capital formation and Consumption of fixed capital related to ecological assets. Then, the counterpart of the ecological debts, the receivables, would also be recorded for the institutional sector called "nature". These would be recorded as financial assets, but would appear in the natural capital account because of their special nature, which is not linked to the financial capital provided to companies, but to their natural origin.

From an accounting perspective, for example, changes in such an aggregate indicator from one accounting period to the next could be broken down and interpreted in the same way as the SNA categories for changes in assets and liabilities (United Nations et al., 2009, para. 12.1-3). These categories would be as follows:

1. changes in the state of the ecosystem attributable to an economic unit (for example, the destruction of a hedge by a farmer or the revegetation of a degraded area by a manager); treated as "economic transactions",
2. changes in the state of the ecosystem resulting from exogenous causes (for example, damage to a coral reef caused by a hurricane); treated as "other changes in volume",
3. changes in reference levels reflecting changes in collective preferences¹²²; treated as "other volume changes",
4. changes resulting from improvements in data and valuation methods; treated as "other changes in volume",
5. technical progress and price trends affecting the cost of maintenance and restoration work required to achieve the corresponding reference levels; treated as a "revaluation" (change in price level or structure).

We would record them in existing accounts.

¹²² The variation in prices can be interpreted as resulting from changes in individual preferences and the variation in public spending as resulting from changes in collective preferences in the National accounting.

Table 18 Asset variation account including a new natural capital account

Change in assets	Explanations
Capital account	
Gross fixed capital formation - operating cycle	Conventional GFCF
Consumption of fixed capital - operating cycle	Conventional CFC
	Individualisation of GFCF on capital preservation assets (e.g. wastewater treatment plant, carbon capture and storage facility).
Gross fixed capital formation - preservation cycle	Corresponding CFC
Consumption of fixed capital - preservation cycle	
Net lending (+) or borrowing (-)	
Natural capital account	
	GFCF linked to the consumption of new natural capital. Fixed assets linked to the permanent degradation of natural capital.
Formation of natural assets - uses	Current assets
CO storage ₂	Current assets
Ploughed soil	Fixed assets
Degraded ecosystem and stable soil	Current assets
Nitrogen storage	
Consumption of natural assets - uses	
CO ₂ storage	
Ploughed soil	
Degraded ecosystem and stable soil	
Nitrogen storage	
Natural assets - commitments	Account used by the "nature" institutional sector to record offsets to ecological liabilities
Natural credits - Climate	Ecological claims on climate capital
Natural credits - Agricultural soil	Ecological claims relating to agricultural land
Natural credits - Protected habitat	Ecological claims concerning protected habitats
Natural credits - Water bodies	Ecological claims concerning the climate
Financial account	
Cash and cash equivalents	
Debt securities	
Credits	
Other changes and volume adjustments	
Non-financial assets	
Natural assets - uses	
Natural assets - commitments	
Financial assets	
Revaluations	
Non-financial assets	
Natural assets - uses	
Natural assets - commitments	
Financial assets	

The place of current preservation expenditure that reduces ecological debts when (biophysical) capital improvement is observed is not yet determined: it can either remain in GDP by recording an additional transaction when the biophysical balance of monetary debt is observed; or it can be reclassified from the Intermediate consumption account to the Change in wealth account because it directly influences the stock of liabilities. Whichever way these expenditures are treated, preservation fixed capital would ideally be individualised in the (conventional) capital account.

Figure 34 shows how an ecological debt account could be constructed alongside National accounting and ecosystem accounting. Whether conducted within or outside official statistics, interpretations of the resulting aggregate indicator and its variations may depend on the perspective adopted for its implementation.

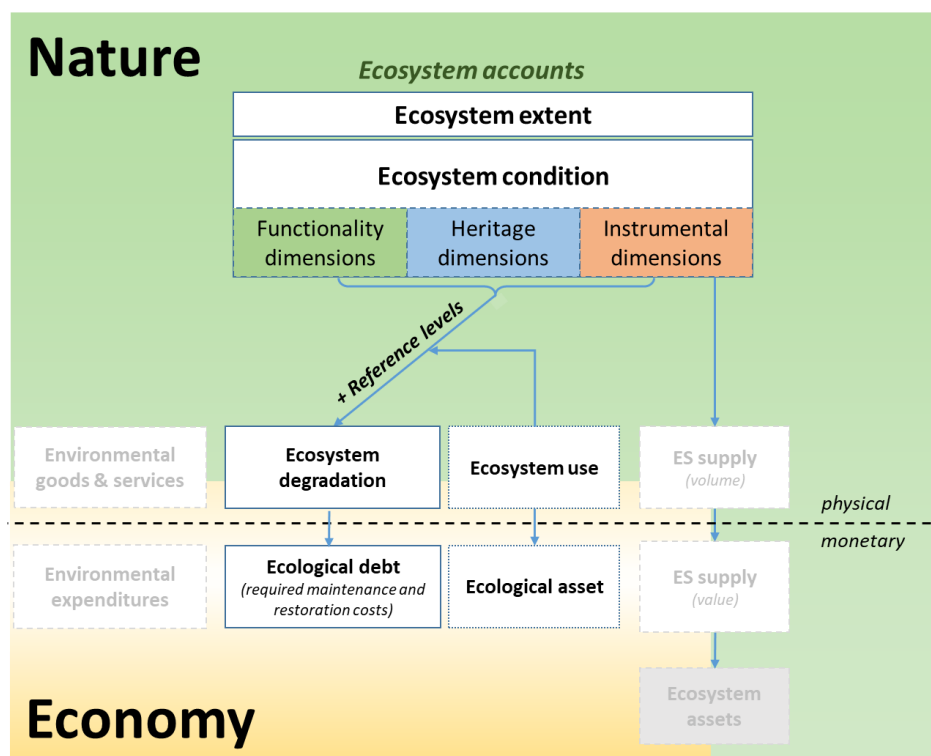


Figure 34 Structure of the accounts derived from an ecosystem monitoring framework

Comment: The boxes reflect different accounts. Some of these components are already required in statistics such as the biophysical side of the SEEA-EA. Other components are not explicit in the SEEA-EAE. The accounts specific to the nature information system are in the green zone, the accounts common to the economy and nature are in the yellow zone. The accounts in grey may have to be produced in a specific institutional context because they may not meet certain quality criteria for official statistics. Under certain conditions, existing accounts represented by dotted boundaries could provide useful information for monitoring pressures (e.g. ecosystem use) or tracking actions taken and their effectiveness, thereby promoting learning about solutions (e.g. environmental goods and services accounts). Source: adapted from Comte et al. (2020).

Interpreting these costs as an ecological debt, i.e. as a liability that should be paid at a given point in time, requires an appropriate choice of reference levels. We now turn to this point.

3. Good ecological status as a boundary object for strategic discussion of environmental objectives and reference levels

While recognising that there is a wide range of approaches, the SEEA WA recommends defining reference condition levels "using the natural state as the reference condition" (United Nations 2021, § 5.72). This is because the methodology "should allow accounts to be developed that are free of value judgements and do not imply a policy objective or desired condition" (Keith et al., 2020). However, to be interpreted as an ecological debt, the costs required to achieve certain reference levels, both on the extent and state of ecosystems, should be linked in some way to our collective willingness to pay

for the maintenance and restoration of ecosystems¹²³. For this reason, Vanoli (2017) estimates ecological debt on the basis of environmental standards determined "in the form of societal norms", as revealed by policy objectives. Although simple in principle, such a perspective raises difficult practical issues. It also requires assessment to be seen as part of a wider socio-political process, as argued for example by Godard and Laurans (2008). In this section, we examine how a collective willingness to pay for the maintenance and restoration of ecosystems can emerge from a dynamic political process involving different communities around the discussion and collective legitimisation of the objectives defining good ecological status.

A detailed description of such a process requires first of all a careful examination of the way in which the scientific, political and administrative spheres can be involved in the dynamic processes of defining and implementing objectives at different scales. Thus, we will also describe good ecological status as a frontier object, involving different communities without leading them to radically change their references. To define such a process, we will draw on the useful distinction between environmental limits, standards and objectives, originally proposed by Usubiaga-Liaño and Ekins (2021) focusing on the processes and communities involved in their construction. *Environmental limits* come from scientific arenas. They warn of the risks of crossing specific thresholds, as, for example, Steffen et al, Steffen et al (2015) have done at global level with planetary limits. Although they may include some normative content, they leave the most crucial trade-offs to public discussion. *Environmental objectives* are developed as part of the political process, whose role includes ensuring the legitimacy of collective choices and constructing political preferences by weighing up economic and social considerations. At this level, environmental objectives may be expressed in laws, regulations, plans and strategies. However, they may still be insufficiently coherent, specific, measurable, ambitious or realistic to be implemented¹²⁴. Consequently, we can define *environmental standards* as specifications of environmental objectives made by the administration in order to implement them.

With these distinctions in mind, it is possible to describe an ideal socio-political process that articulates - rather than opposes - existing assessment approaches for the sustainable management of ecosystems. Firstly, the warnings given by scientists lead, for example, to the identification of limits beyond which the population is exposed to risks or other considerations. In political arenas, discussions and interactions between politicians, scientists and the public lead to the definition of science-based environmental objectives. These objectives are then translated into operational standards at the relevant levels for implementation. (Commons, 1970). Of course, this process is fundamentally iterative and dynamic. Scientific advances can lead to updates in environmental limits, just as societal changes can lead to changes in objectives and associated standards. Inconsistencies between different environmental standards can also lead to the adjustment of targets.

Alongside other scientific contributions, ecosystem accounts can provide information for this process at various levels, as illustrated by the following diagram (Figure 35). In political arenas, knowledge about Ecosystem services could complement knowledge about environmental limits with economic and social considerations to define targets. In turn, standards clarify residual trade-offs or the realism of existing targets by making explicit the required measures and associated costs, which may lead to

¹²³ The idea that it is possible to define a pristine natural state on objective grounds is also controversial, since humans have shaped ecosystems over a very long period of time (Ellis et al., 2021).

¹²⁴ These requirements are the widely-used SMART criteria: "Specificity", "Measurability", "Ambition", "Realism" and "Time-bound". More specifically, "specificity" requires that targets be set at levels appropriate to implementation (scales, time horizons, sectors); "measurability", that indicators be assessable, so that progress towards targets can be monitored; "ambition", that the standard used be fully consistent with the ambition of existing targets; and "realism", that a credible action plan for achieving the related targets be spelled out.

their revision as part of an iterative dialogue. Such processes are already underway, for example, in the management of continental aquatic ecosystems in the European Union, where disproportionate costs may justify a relaxation of targets, by extending the deadline for achieving good status of water bodies (see, for example, Boeuf et al., 2018). The gap between existing targets and actual policies, as documented by ecological debt and its evolution, could also increase accountability in the political sphere and call for adjustments in ambition or actions.

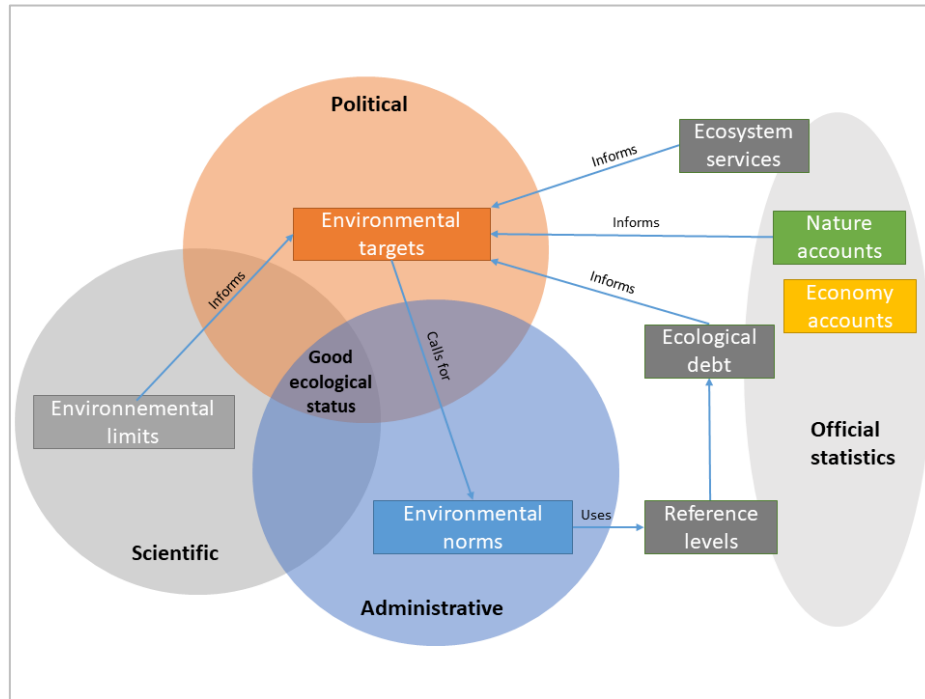


Figure 35 Good ecological status and ecosystem accounts as boundary objects in the strategic discussion of environmental objectives.

Comment: Each of the spheres brings together a diversity of stakeholders with appropriate governance systems. The arrows represent some of the possible interactions between spheres around the objects presented in this article. They are not exhaustive of the complex and changing interactions between these spheres. For example, the environmental objectives set in the political sphere may be informed by scientific data concerning environmental limits, but also by social and economic information built around the accounts of nature and economics, for example concerning losses of Ecosystem services or the cost of access routes to the objectives. In turn, targets can be used to establish the most appropriate environmental standards to provide robust reference levels that can be used to provide robust information on the effort required to achieve good ecological status.

It should be noted at this stage that such an indirect approach to evaluation makes it possible to produce a meaningful macro-aggregate indicator without restricting the expression of the values that govern the formulation of objectives. These values may be expressed by a diversity of stakeholders with different interests, concerns and worldviews, including ethical, symbolic or identity-related considerations. They may not even pre-exist, but emerge from individual reflections and public discussions. This indirect approach to assessment may be particularly relevant, as the management of ecosystems and their biodiversity requires consideration of their complex functioning (OECD, 2018b) the formation of value (Sen, 1995) and pluralism (Pascual et al., 2021).

4. Focusing on what matters: the extent and state of ecosystems as part of a vast information system on nature

At this stage of the argument, it must be clear that no meaningful monetary indicator of ecosystem degradation can be obtained in the absence of robust and relevant biophysical monitoring of the extent and state of ecosystems¹²⁵. This requires the identification of relevant dimensions, i.e. those linked to specific values¹²⁶, explicitly or implicitly, on the basis of existing objectives. In particular, estimating an ecological debt using the cost-based approach requires careful attention to variable selection so that all dimensions subject to environmental standards as defined above are controlled. Consequently, we examine here how such an intention in terms of monetary valuation could, in turn, shape accounts of the extent and state of ecosystems.

Currently, the measurement of ecosystem extent is organised around the SEEA reference ecosystem classification types, based on the IUCN Global Ecosystem Typology (GET). The measurement of the state of ecosystems is organised around the SEEA EA ecosystem state typology (ECT). This typology is still mainly based on natural science categories, where links with values are established by using two indicator selection criteria: instrumental or intrinsic relevance (Czúcz et al., 2021; United Nations, 2021). In order to strengthen the accounting of ecosystems as a frontier object, Comte et al. (2020) propose to structure a dashboard of the state of ecosystems according to three categories motivated by an explicit relationship with existing policy objectives and underlying values, so that all dimensions of interest can be specified with the underlying rationale for their monitoring. Each of these categories is linked to the value concepts invoked to justify the management objectives, which are of three different types.

- *Heritage* dimensions include ecosystem features that are considered remarkable for one reason or another. The interest in monitoring these dimensions stems from the non-use values or intrinsic values associated with these specific elements and which are invoked to justify the conservation objectives.
- The dimensions of *use*¹²⁷ include the characteristics of ecosystems that determine their capacity to provide specific Ecosystem services sustainably¹²⁸. The advantage of monitoring

¹²⁵ The dimensions of interest may be related to the extent or state of ecosystems, as some forms of ecosystem degradation (e.g. drainage of wetlands, deforestation for agriculture, conversion of grassland to cropland, desertification, land grabbing or coral reef bleaching) may be reflected in the accounts as changes in type, depending on the ecosystem typology chosen.

¹²⁶ We understand value here in a broad and inclusive sense, in line with the recent IPBES (2022) key messages for policy makers. These may be use values, but also, for example, values as principles, such as the precautionary principles that motivate safe minimum standards in the spirit of the global limits framework (Rockström et al., 2009; Steffen et al., 2015).

¹²⁷ Although we have reformulated the term capacity, initially used by Comte et al (2020), we retain an "upstream" perspective by considering in this category the dimensions included in the measurement of ecological status that inform us about the capacity of ecosystems to provide specific services in a sustainable manner, as are, for example, the indicators associated with descriptors 3 and 9 of the Marine Strategy Framework Directive. These dimensions are interesting because they can be directly linked to the ecosystem's capacity to provide a given service sustainably and at an optimal or satisfactory level (for example, the distance from maximum sustainable yield for the different dimensions of a fish stock). They are not necessarily one-dimensional and need not be expressed in the same unit as the Ecosystem service concerned, as recommended by the SEEA EA (United Nations, 2021, § 6.149) for capacity.

¹²⁸ Ecosystem services are broadly defined as "the benefits that people obtain from ecosystems". (Millennium Ecosystem Assessment, 2003). We define benefits as an increase in an explicit dimension of individual or collective well-being, such as those identified by the Stiglitz, Sen and Fitoussi Commission (Stiglitz et al., 2009b).

these dimensions comes from the benefits (use values) invoked to justify certain optimal management objectives (for example, maximum sustainable yield for fisheries), possibly tempered by existing trade-offs with other dimensions.

- Finally, the dimensions of *functionality* include the characteristics of ecosystems that guarantee the maintenance of their overall resilience and functionality. The value of monitoring these dimensions lies in the values invoked to justify the promotion of ecosystem resilience and the maintenance of pressures within a safe operating space. There is no reference to specific Ecosystem services or outstanding features¹²⁹.

These three categories reveal three main logics that are often opposed, neglected or prioritised in ecosystem monitoring and management. For example, the logic of functionality dominates in the frameworks of planetary limits (Rockström et al. 2009, Steffen et al. 2015) or the environmental sustainability gap (Usubiaga-Liño and Ekins 2021). The dominance of the use logic in the SEEA EA is also worth highlighting, at least when it comes to choosing what will be taken into account in the monetary accounts (United Nations, 2021).

This categorisation is useful for ensuring an exhaustive selection of variables of interest. It recognises that each variable has its own logic and legitimacy for ecosystem monitoring and management, without ranking them in order of importance. It makes it possible to build an ecosystem monitoring system that does not create a priori power asymmetries and that is capable of supporting a diversity of political projects. Such a framework therefore encompasses a broad and inclusive field of application, which is both consistent with the SEEA EA approach to the state of ecosystems (Keith et al., 2020) but also with the increasingly recognised need to adopt diverse valuation perspectives in accounting and policy-making (see, for example, Pascual et al. (2021) or IPBES (2022), messages KM7 and B7).

Comte et al. (2020) also show that these categories can easily be mapped to the descriptors defining good environmental status (GES) for integrated marine ecosystem management, thanks to a quick match with the descriptors defining good environmental status in the Marine Strategy Framework Directive (MSFD) (Figure 36). They also note that the "functionality" category provides a rationale for most of the dimensions defining good environmental status in the marine environment (8 of the 11 descriptors), underlining the importance of a holistic perspective on ecosystem functionality for effective management.

¹²⁹ These values, such as the precautionary principle, are closely linked to our collective attitudes to risk and uncertainty.

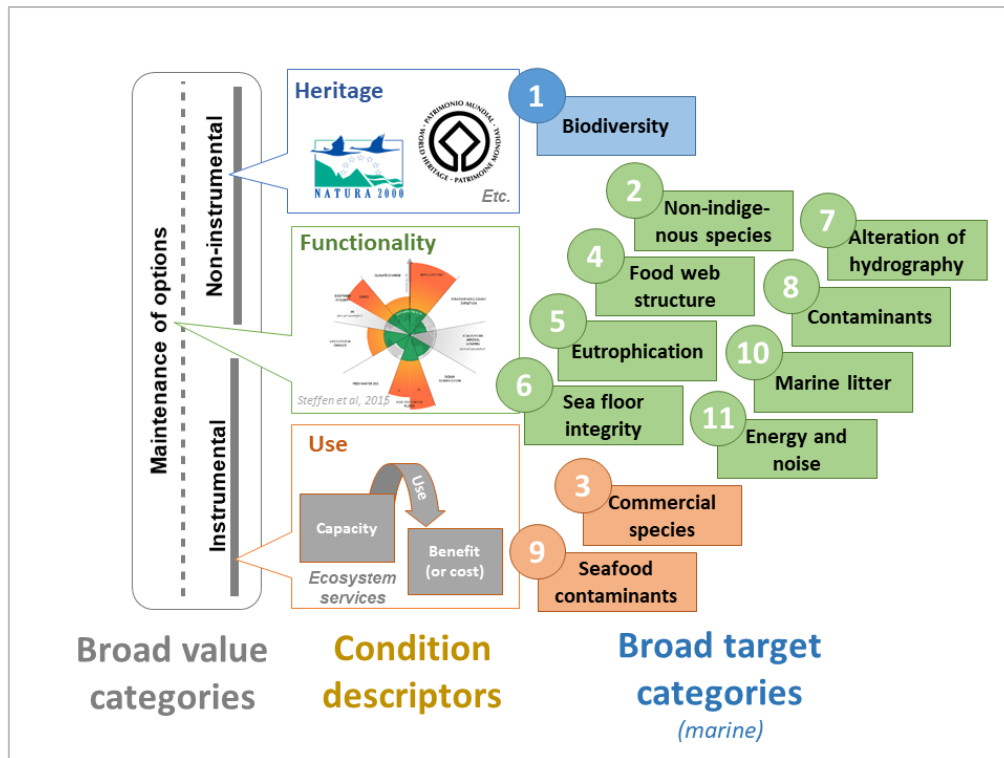


Figure 36 Links between categories of ecosystem status indicators, major value concepts and major categories of integrated management objectives, using the example of the EU Marine Strategy Framework Directive.

Comment: The "heritage" category includes the state of conservation of all the elements of ecosystems with intrinsic or other value, recognised by labels of various kinds (species of community interest in the EU, world heritage, etc.). The "functionality" category refers to the dimensions that need to be monitored to ensure that the overall functionality of the ecosystem is not threatened, as indicated by resilience indicators or when certain pressures exceed specific safety thresholds. Finally, the "use" category relates to all the direct determinants of the capacity of ecosystems to contribute to specific dimensions of human well-being (Ecosystem services). The objective categories are the 11 descriptors of good environmental status in the EU Marine Strategy Framework Directive. Credit: the global limits were designed by Azote for the Stockholm Resilience Centre, based on analyses by Steffen et al. Persson et al (2022).

Such a typology bridges the gap between communities and addresses some of the issues identified in the SEEA EA research and development agenda (United Nations 2021, p. 348). In particular, this typology ensures that all relevant non-instrumental dimensions (heritage and functionality) are taken into account by making explicit links to underlying values. This allows the broad and inclusive perspective of values in monetary valuation and accounts to be reflected through the indirect and dynamic valuation approach discussed in previous sections¹³⁰. The 'functionality' category, driven by the recognition of the complexity of ecosystem functioning, also provides a compelling rationale for tracking specific dimensions of ecosystem resilience and pressures as a value in its own right, even in the absence of an explicit link to certain Ecosystem services or to intrinsic value. We stress that the accounting system must provide such monitoring in order to support current policies and complementary valuation approaches, such as those discussed in this article. As the existing objectives reveal, the dimensions required cover specific aspects of ecosystem status (e.g. plastic waste in the

¹³⁰ With regard to non-use values, we find in the SEEA-EA that "it is not considered, from an accounting point of view, that a transaction has taken place in accordance with the framework used for recording ecosystem services in the SEEA EA", so that "these values can only be presented in complementary assessments" (United Nations 2021, §6.72-73).

oceans), but also the attribution of specific changes in ecosystem status to human activities (e.g. fishing mortality) or to pressures that cannot be easily linked to changes in ecosystem status. The latter is due, among other things, to delayed impacts or natural variability (for example, the use of pesticides or excess nitrogen in agriculture). At present, the SEEA EA only includes pressure indicators in the state accounts as substitutes for state indicators (United Nations 2021, §5.103). This should be given particular attention, as it may lead to key information on functionality issues being overlooked.

5. Conclusion - A research and action programme

In this paper, ecosystem accounting and related data are defined as part of a broad nature information system designed to support policy making and other uses. This leads us to establish an explicit link between the dimensions of interest and the multiple underlying values that motivate their monitoring. This provides a sound basis for discussing, developing and prioritising monitoring efforts. It also leads us to emphasise the need to complement the SEEA EA guidelines by placing greater emphasis on sustainable management issues, pressures, solutions and their costs. Such an information system would extend and build on the rich data that already exists to support integrated ecosystem management policies.

An indicator of ecological debt could be derived from such a system and included in the sustainability scorecards (Stiglitz et al., 2009b). Making the degradation of ecosystems visible alongside other dimensions of national progress may prove to be effective. Since it is a monetary indicator, comparisons with wealth creation measured by GDP can be facilitated and concerns about ecosystems can become more important in budget discussions. More importantly, as with GDP, such an aggregate indicator (the destination) can be useful not only in its own right, but also through the whole information system associated with it and the processes that accompany its production (the journey). One of the main advantages of this approach is to channel economic evaluation efforts from those focused on justifying action (e.g. the cost of inaction) to those focused on action and solutions, more in tune with the needs of policy and decision makers. From support for integrated ecosystem management¹³¹ to the design of policy instruments¹³², many potential uses could emerge. With an associated ecological debt as a flagship indicator, such an accounting system can be used in a measure comparable to GDP and associated economic accounts.

The potential uses of ecosystem accounts are therefore numerous, but we need more evidence that these uses may be more than speculative or anecdotal (IPBES 2022, messages KM7 and B7). Further discussion and research is needed to identify and specify these potential uses (and the underlying theories of change¹³³), validate them and discuss their relative relevance in supporting the transition to sustainable societies (IPBES 2022, message B7). Work is also needed to strengthen a framework for co-construction, in addition to the "technical push" that has largely dominated the development of the accounts to date (Vardon et al., 2016). It is also clear from this discussion that many technical issues

¹³¹ Firstly, it should be noted that measures of the costs of degradation on a national scale are already explicitly required, for example in the initial assessment of the Water Framework Directive (Levrel et al., 2014b).

¹³² For example, reducing environmentally harmful subsidies and increasing payments for environmental services, environmental taxation, green public procurement or disclosure of environmental information.

¹³³ A theory of change is an explicit account of how an intervention (for example, here, the development of a specific ecosystem account or indicator) would lead to specific outcomes over different time horizons. By requiring an explicit representation of the causal links between an intervention and its impacts, it provides the basis for rational discussion. For examples of links between accounting and conservation outcomes, see, for example, Feger et al (2018) or Mermet et al (2013).

would require further investigation, for example regarding the relative merits of typologies for ecosystem types or their condition, different ways of defining reference levels or relevant categories for accounting treatments. However, these important discussions could not be resolved rigorously without explicit and specific identification of the main intended uses of the accounts and their context.

Chapter 5- Accounting for terrestrial biodiversity: artificialisation and protected species

Warning:

This chapter benefited from the work of two interns (Morgane Gonon and Antoine Levasseur) supervised by the PhD student and Harold Levrel. Morgane Gonon contributed to the general framework, the literature review, and the collection and processing of data on No net land-take and preservation costs. By analysing 19 environmental impact assessments, she helped prepare Antoine Levasseur's internship, who compiled data on 36 development projects.

The synthesis of this work, the additional studies (updates, corrections, additions) and the writing of this chapter were carried out by the doctoral student.

1. Introduction

Biodiversity is often seen as an elusive concept that cannot be quantified. Its complexity and the various values attached to it seem to make any attempt to reduce it to a figure futile. The first is opposed to the necessary simplifications and selections of dimensions to be measured, which do not do justice to ecological and evolutionary phenomena. The question of values gives rise to debates which, at first sight, seem insoluble as to what is desirable to conserve and at what level.

Yet biological diversity was originally a quantified concept. Its first definition was as follows: *"Biological diversity refers to the variety and variability among living organisms and the ecological complexes in which they occur. Diversity can be defined as the number of elements and their relative frequency. [The term encompasses different ecosystems, species, genes, and their relative abundance. (U.S. Congress, Office of Technology Assessment, 1987). However, the definition of this initially scientific term has evolved as it has spread to wider spheres (Blandin, 2014). It became increasingly encompassing, becoming synonymous with "nature" or the biosphere, and the idea of quantification was lost. The development of the notion of biodiversity has therefore opened up an infinite number of possibilities for quantifying nature.*

Quantification is a solid basis for management (Desrosières, 2010; Espeland and Stevens, 2008). It is therefore necessary to go beyond this apparent insolubility if we hope to preserve the remaining diversity of living things. The next step is to mobilise these metrics in accounts capable of organising discussions on the relationship between the economy and nature. This tool can structure the interactions of diversified players who effectively manage natural elements (positively or negatively) (Feger and Mermet, 2021b; Rambaud and Feger, 2019).

We set out our problem in the general introduction to the thesis: why and how should national and corporate ecological debts be articulated? Chapter 1 clarified this question by providing three lines of research: on accounting conventions, on the micro-macro link, and on the uses of accounts. This chapter therefore addresses three research questions.

The first is based on the observation that there is no National accounting system for biodiversity, ecosystems or nature that would make it possible to monitor the commitments made in favour of biodiversity and to implement a national economic policy for biodiversity based on strong sustainability. The ecosystem accounts of the SEEA (Committee of Experts on SEEA EEA, 2021) or true savings (World Bank, 2006) are based on weak sustainability. Approaches based on strong sustainability, such as the *"Ecosystem natural capital accounts"* (ENCA) (Weber, 2014) or Unpaid Ecological Costs (Vanoli, 2017) do not detail the methods for estimating costs, nor the procedures for selecting the entities to be preserved and the corresponding metrics. Moreover, the experiments in Vanoli's framework do not concern terrestrial biodiversity (CGDD et al., 2015). We will therefore take up the design of ecological debt accounts on the basis of the CARE model and Vanoli's work. Now that our general accounting structure has been defined (Chapter 4), we need to specify what will come under terrestrial biodiversity. We will therefore ask ourselves: what aspects of nature can be included in such National accounting? What metrics should be used? Can we go so far as to estimate monetary debts? We will try to take a practical look at these questions by studying the available sources of data.

A second line of research focuses on understanding the links between the levels of the individual (or organisation), the nation and what lies between the two. What micro-macro links can we build on? We can also take a practical view and study the links that already exist in the information systems that

describe biodiversity and its management. On this second point, what links need to be built to establish National accounting?

A third point of attention concerns what can be done with such ecological debt accounting. What are its potential uses? What do the accounting conventions used allow? In particular, we will discuss how the accounting dimension reinforces or renews the use that could already be made of hitherto separate quantifications.

This work is based on two major aspects of French biodiversity policies: the objective of no net land-take, set for 2021 in the "Climate and Resilience" law, and environmental impact assessments (linked to the Avoid, Minimise, Restore, Offset sequence), which include a section on protected species and habitats. These two policies focus mainly on the pressure of development, which is the main pressure on biodiversity in mainland France, along with agricultural issues. (Balvanera, Patricia et al., 2019; Ministère de la Transition écologique et solidaire, 2019a; Rouveyrol and Leroy, 2021). The general objective of this chapter is to study the existing articulation between these frameworks in order to see if it is possible to merge them into a common National accounting.

The chapter therefore combines general framework elements (scope of regulations, definition of the environmental components described, etc.) in the first part, with data collection and formatting work. This second part includes the mobilisation of data from the Statistical Service of the Ministère de la Transition écologique, data from reports, and the creation of a database based on the analysis of thirty-six Environmental impact assessments. Some of these values will be presented in an extended national accounts sequence. We will conclude this chapter with a discussion that responds to the three lines of research.

2. Identifying and defining "terrestrial biodiversity" capital

In the CARE model, the definition of the capital that will appear on the liabilities side of the balance sheet requires the identification of three key elements: a concern for preservation, i.e. a more or less widely shared desire to preserve a given environmental entity. This is what will make it possible to define the representatives of the capital (of the entities to be maintained). In our case, we will consider that the concern comes from the State, which requires us to look at the legislative texts relating to the preservation of terrestrial biodiversity.

The second element is the existence of translators to represent the environmental entity. At local level, these can be very varied (experts, another environmental entity, etc.). At national level, indicators are preferred for their capacity for transfer, harmonisation and stability (Espeland and Stevens, 2008). We will find them in the corresponding texts.

Finally, we need to be able to define levels of capital preservation. In environmental accounting and in public policy, this goes by various names. The most common are thresholds, reference levels, targets or good ecological status (see for example Keith et al., 2020).

2.1. Texts used to define preservation concerns

Unlike other elements of biodiversity (aquatic environments, genetic aspects), there are many legislative texts dealing with terrestrial biodiversity and they cover a fairly wide range of entities. As a result, the metrics used are quite different and it is not always possible to compare or aggregate them. In addition, but this seems natural, it is not possible to define a "total", complete or exhaustive entity from the union of these regulations. Attempts have been made to measure "biodiversity" in this way, but outside a regulatory framework (UNEP-WCMC et al., 2022).

Here we distinguish between two types of text. The first type specifies macro and top-down objectives, i.e. above all collective and national objectives. The second type of text contains explicit micro objectives, which implies, on the contrary, defining first and foremost individual obligations or commitments¹³⁴, which can be assessed in aggregate on a meso and macro scale.

2.1.1. From the macro to the micro: natural, agriculture and forest areas and urbanisation

The Climate and Resilience Act¹³⁵ passed in August 2021 sets a target of no net land-take by 2050, with a milestone of 2030, by which time land-take should have halved compared with the decade 2011-2021.

This law contains provisions that come under a programming law (general frameworks or objectives that do not create standards, but guide the action of the State and the country), and others that are normative and come under an ordinary law (Council of State, 2021). However, the normative dimensions relate primarily to spatial planning. Economic players and individuals are affected by easements created by local town planning schemes (PLU). These are administrative restrictions on property rights.

The obligations linked to the NNLT objective therefore have an impact on spatial planning documents. These must incorporate the objective progressively: at regional level by August 2023, at territorial level

¹³⁴ When we use the terms micro or macro here, we must not confuse the type of commitment (individual or not) with the coverage of the legislation, which is national (we could think "macro") in both cases.

¹³⁵ LAW no. 2021-1104 of 22 August 2021 to combat climate change and build resilience to its effects.

by 2026 and at local level by 2027. In addition, as local authorities cannot act as guardians of one another, the only possible way to ensure compatibility between documents is to request that they be compatible.

Finally, the law provides for the artificialisation of land to be taken into account in the environmental assessment of projects. This takes the form of a "building density optimisation study".

2.1.2. From micro to meso: protected species and habitats and impact assessments

At company level, capital linked to the notion of terrestrial biodiversity can be defined using different frameworks. Existing extra-financial reporting frameworks (annual declaration of extra-financial performance, international standards¹³⁶) do not yet allow this, as environmental entities are not defined in a harmonised way and many choices are left to companies. This is particularly true of the European extra-financial report currently being stabilised (as part of the *Corporate Sustainability Reporting Directive*), which does not require biodiversity indicators beyond the existing legal scope, that of the Birds and Habitats Directives.

On the other hand, less systematically than an annual report, organisations are subject to administrative procedures when they are planning certain activities or projects that are potentially dangerous for society or the environment. Environmental authorisation requires the impacts of projects to be published in an impact assessment (EIA). They are based on national environmental law¹³⁷ (and European law¹³⁸). Most projects subject to environmental authorisation must also follow the "avoid, minimise, restore, offset" sequence, which aims to achieve No net loss of biodiversity. This is not the case for forest clearing or agricultural compensation (Alligand et al., 2018, pp. 14-15). Thus, these triggers may include conservation concerns shared at national level (Table 19).

We have separated these reasons into two columns to show those that can be used to define "hollow" capital and those for which the capital to be preserved is explicitly defined. In the first case, the reasons explicitly refer to the preservation of entities for which there is a preservation concern defined elsewhere. The corresponding texts are listed in Table 20. In the second case, the reasons can only be deduced from the analysis of the impact assessment, although there is no a priori request to preserve particular entities.

¹³⁶ These include the *Global Reporting Initiative*, the *International Sustainability Standards Board* and the *Taskforce on Nature-related Financial Disclosures* (TNFD).

¹³⁷ In particular, articles L181-1 to L181-32 of the French Environment Code on administrative procedures and articles R122-1 to R122-14 of the French Environment Code on impact assessments for works, structures or development projects.

¹³⁸ Directive on impacts (amending French law, in particular by decree 2022-422 of March 2022).

Table 19 Triggering the environmental authorisation procedure and definition of natural capital

Legal code	Triggered by an impact on explicitly defined natural capital	Procedure for defining "hollow" capital
Environment Code	<ul style="list-style-type: none"> Derogation from compliance with good status objectives for bodies of water¹³⁹ Special authorisation under the legislation governing national nature reserves or Corsican nature reserves Special authorisation under classified sites legislation <u>Exemptions to the ban on damage to protected species and habitats</u> Natura 2000 impact assessment 	<ul style="list-style-type: none"> Authorisation for Installations classified for the protection of the environment (ICPE); or installations, works and activities (IOTA) relating to aquatic environments. Approval for the use of genetically modified organisms (GMOs) Approval of waste treatment facilities IOTA declaration; ICPE registration and declaration
	Case-by-case assessment: the environmental authority may initiate a declaration or authorisation procedure if there is a "possible significant impact", with the possibility of doing so for "small projects" since March 2022 ¹⁴⁰ .	
Forestry code		Clearance authorisation (Article L.341-6 of the Forestry Code)
Energy Code		Authorisation to operate electricity generation facilities.
Transport Code, Defence Code, Heritage Code		Authorisation for the installation of wind turbines, or for road or rail infrastructure "State"
Town Planning Code		Additional procedures

Legend: in bold, the elements that will be the subject of particular attention in this chapter. Underlined: cases for which we have collected data (see following sections). Source: author, based on Alligand et al (2018), Gonon (2021) and the Environment Code.

These texts apply in cases where impacts are anticipated on elements that are considered to be sufficiently important (for whatever reason: to use the typology described above, this may be for reasons of heritage, instrumental or ecosystem functioning) to manage their deterioration and request preservation. This includes elements benefiting from strong protection for which there are derogation procedures. This case is to be distinguished from elements of the environment for which there is an unsurpassable prohibition on degradation. In this case, their management is not subject to the accounting system we are proposing.

¹³⁹ This case is dealt with in Chapter 6.

¹⁴⁰ [Decree no. 2022-422 of 25 March 2022](#)

Table 20 National regulations for defining micro natural capital

Legal texts	Scientific ontology	Administrative ontology ("spaces")
Nature Protection Act (1976) ¹⁴¹ Habitats, Fauna and Flora" Directive (1992)¹⁴²; "Birds" Directive (1979¹⁴³ and 2009¹⁴⁴); implementing legislation; Successive decrees changing the lists ¹⁴⁵	Protected species	Natura 2000 site ¹⁴⁶
Habitats, Fauna and Flora" Directive (1992); transposition laws ¹⁴⁷	Protected habitat	
Act of 2 May 1930; Nature Protection Act (1976); Local Democracy Act (2002) ¹⁴⁸		Reserves and classified sites (natural or otherwise)

Legend: in bold, the elements we work on in more detail below. Source: author.

The ontology of the capitals may be mainly scientific (species and natural habitats) or administrative (natural areas¹⁴⁹). In the case of protected species and habitats and Natura 2000 sites, there is a deliberate geographical overlap of capitals, as the sites have been positioned, among other things, to contribute to the preservation of protected species and habitats. Thus, 29.2% of the ranges of these habitats and 24.6% of the ranges of these species are found in Natura 2000 sites (Rouveyrol and Leroy, 2021, p. 84)..

In this chapter we will focus on the protected species and habitats set out in the nature directives. This represents 306 species and 132 habitats in France (Table 21).

¹⁴¹ LAW no. 76-629 of 10 July 1976 on the protection of nature.

¹⁴² Council Directive 92/43 BA of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora.

¹⁴³ Council Directive 79/409 BA on the conservation of wild birds.

¹⁴⁴ Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds.

¹⁴⁵ See the [inventory of modifications drawn up by the French National Museum of Natural History](#)

¹⁴⁶ It is debatable whether Natura 2000 areas should be considered as capital. They can in fact be seen as simple tools, places of management, prevention of degradation and receipt of funding, to contribute to the preservation of species and habitats of Community interest (Rouveyrol and Leroy, 2021, p. 18).

¹⁴⁷ Law no. 2010-788 of 12 July 2010 on the national commitment to the environment.

¹⁴⁸ LAW no. 2002-276 of 27 February 2002 on local democracy.

¹⁴⁹ National parks are not included here, as authorisations for projects in these areas are subject to different procedures that we have not studied.

Table 21 Number of protected species and habitats in France

Protected species and habitats	Number
Species	715
Amphibians and reptiles	121
Chiropterans	121
Aquatic species	70
Marine species	48
Flore	145
Insects	129
Land mammals (excluding chiropterans)	55
Molluscs and others	26
Habitat	315
Agropastoral habitats	83
Aquatic and wetland habitats	71
Forest habitats	68
Coastal and dune habitats	39
Marine habitats	16
Rocky habitats	38
Grand total	1030

Once capital has been identified in words, it is necessary to quantify its characteristics in order to introduce it into the accounts. This translation is important, because it is on this basis that management decisions will be made.

2.2. Definition of preservation indicators and thresholds

2.2.1. Notion of artificialisation and preservation trajectory

In the "Climate and Resilience" law, "artificialisation is defined as the lasting alteration of all or part of the ecological functions of land, in particular its biological, hydric and climatic functions, as well as its agronomic potential through occupation or use" (art. 191).

As there are no data corresponding to this definition at national level, the definition adopted for the first decade of application (2021-2031) is the consumption of natural, agriculture and forest areas (NAFA) (Ministère de la Transition écologique, 2021). In reality, the application decree departs from the usual definition of NAFA (France Stratégie et al., 2019) by classifying quarries in the "undeveloped" category (Table 22).

Table 22 Types of surface area (not) developed (source: [appendix to article R. 101-1 of the town planning code](#); emphasis added)

Surface categories	
Developed areas	1° Surfaces where the soil is sealed due to buildings (constructions, developments, works or installations).
	2° Surfaces where the soil is waterproofed due to a covering (artificial, asphalt, concrete, pavers or flagstones).
	3° Partially or totally permeable surfaces whose soils are stabilised and compacted or covered with mineral materials.
	4° Partially or totally permeable surfaces whose soils are made up of composite materials (heterogeneous and artificial cover with a mixture of non-mineral materials).
	5° Areas used for residential purposes, secondary or tertiary production , or for infrastructures such as transport or logistics, where the ground is covered by herbaceous vegetation, even if these areas are under construction or in a state of abandonment.
Undeveloped areas	6° Natural surfaces that are either bare (sand, pebbles, rocks, stones or any other mineral material, including the surfaces of quarrying activities) or permanently covered with water, snow or ice.
	7° Areas used for crops , which are planted (agriculture, forestry) or in water (fishing, aquaculture, salt farming).
	8° Natural or vegetated surfaces constituting a natural habitat , which do not fall into categories 5°, 6° and 7°.

We can see here that the capital is the undeveloped surface area. However, is the default capital individual (micro) or national? The question arises because, at first sight, an undeveloped area seems to be a micro, individual entity which falls within the domain of the landowner. It may fall within the scope of the planning document (at the most local level, the local urban plan), where it appears, but this remains close to the individual level. Given that an area can be split up and that the impact is located within a cadastral perimeter, it seems possible to define a micro capital.

On the other hand, the law defines these areas in a generic way, which leads to the creation of an equivalence area comprising all the parcels that meet this definition ("non-developed areas"). A priori, this is incompatible with the definition of micro-capital, as we shall see in the case of protected species and habitats or bodies of water (next chapter). What seems to us to allow us to decide in favour of a national capital, and not an individual one, is the definition of the preservation threshold: the only objective defined in the law is a national one, and therefore for this set of undeveloped areas. Capital would therefore be a national entity. This is consistent with the fact that there is no individual legal constraint *a priori*. This constraint arises at the local level, when the corresponding players receive the artificialisation objective from the higher level and adapt it in their development plan.

Over and above these general considerations, we will use a surface area indicator to quantify built-up areas.

The definition of the preservation threshold can be based on different conventions, which may or may not take account of the initial situation. For example, neutrality (no net land-take) could be taken as the threshold in the first year. That said, given that the current situation is a long way from sustainability and the objective of neutrality, the amount of the ecological debt (biophysical and monetary) would bear little or no relation to what it is actually possible to settle when the debt falls due.

To alleviate this problem, it is possible to adopt a dynamic threshold, which follows a trajectory towards a given level, eventually made sustainable. To draw an analogy with financial practice, this is a kind of debt restructuring: given the distance to sustainability, we accept a deadweight loss or a deferral of repayment for a certain period, until we return to an acceptable level of solvency.

This is the second approach chosen by the law, with a target of neutrality by 2050, and an intermediate stage in 2030. By this date, the amount of land artificially created should have reached half of the total level between 2011 and 2021. Between now and 2050, it is necessary to build a national trajectory of reduction, starting from the current situation (210.8 km² in 2020, for an average of 243.1 km² between 2011 and 2021; CEREMA, 2022). The objective of achieving half the level of artificialisation of the past decade by 2030 gives a total budget of 1,215.5 km² for the period 2021-2030. Given the need to aim for neutrality by 2050, it is recommended to follow a downward trend over the period 2021-2030. If we assume a constant decrease in net artificialisation (which is debatable from the point of view of intergenerational equity criteria), this results in budgets that decrease by 16.2 km² per year, and the values in Table 23. We stop our estimate in 2030, because the definition of artificialisation will change at that date, as we explained above.

Table 23 Annual preservation threshold trajectory for the period 2021-2030

Year	2011-2021	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Net art flow/year (km ²)	2431	210,8	194,6	178,3	162,1	145,9	129,7	113,4	97,2	81,0	64,8	48,5

Legend: in bold, observed values (source: authors, based on CEREMA, 2022).

This objective must then be distributed across the different regions through spatial planning documents. Local implementation therefore involves negotiations between the players responsible for documents at the same geographical level (SRADDET, Scot, PLU).

2.2.2. Conservation status of protected species and habitats: legal framework and practice

The conservation status of species and habitats of Community interest is defined in a similar way in the habitats directives (Figure 37) and the Birds Directive. This definition involves four categories of determining characteristics: range; population size (for species) or area occupied (for habitats); habitat quality (species) or structure and functioning (habitats); and outlook. Most categories are analysed through the prism of an indicator whose value, evolution and deviation from a reference threshold (established according to ecological criteria) are assessed. Perspectives are determined by the pressures and threats identified. A set of logical rules is used to calculate the differences between values and thresholds, and an aggregate score is then calculated for each category. These categories are then aggregated and the conservation status of each species or habitat is assessed by biogeographical region (in France, there are four terrestrial regions: Alpine, Mediterranean, Continental and Atlantic).

To move on to the micro level, we need to turn to impact assessments. Despite the existence of clear legal frameworks and the availability of detailed public data on these species and habitats, we have found that they are rarely used in EIAs. Instead, they contain indicators relating to a fraction of the dimensions of these directives, or indicators defined for the occasion. Moreover, they are not always quantitative, nor are they detailed enough to identify species and habitats individually (the data is often presented by groups of species).

These indicators are compared with the preservation threshold, which is No Net Loss (NNL) of biodiversity. In principle, each project must meet this threshold. This NNL is therefore defined on an *ad hoc basis* for each project, and the project developer must be able to justify in the impact assessment that it does not have a significant impact on biodiversity, or that it implements measures that are ecologically equivalent. This means that the destruction of individuals or the degradation of an environment can be compensated for elsewhere, by the reintroduction of specimens or the creation/restoration of ecologically equivalent environments at a maximum distance specified by the instructing authorities. This is consistent with the definition of capitals, which are general categories, ecological groups (for example, it is the European genet species that must be preserved, as opposed to a very specific genet; or the "Atlantic salt meadows" habitat, not every square metre of salt meadow).

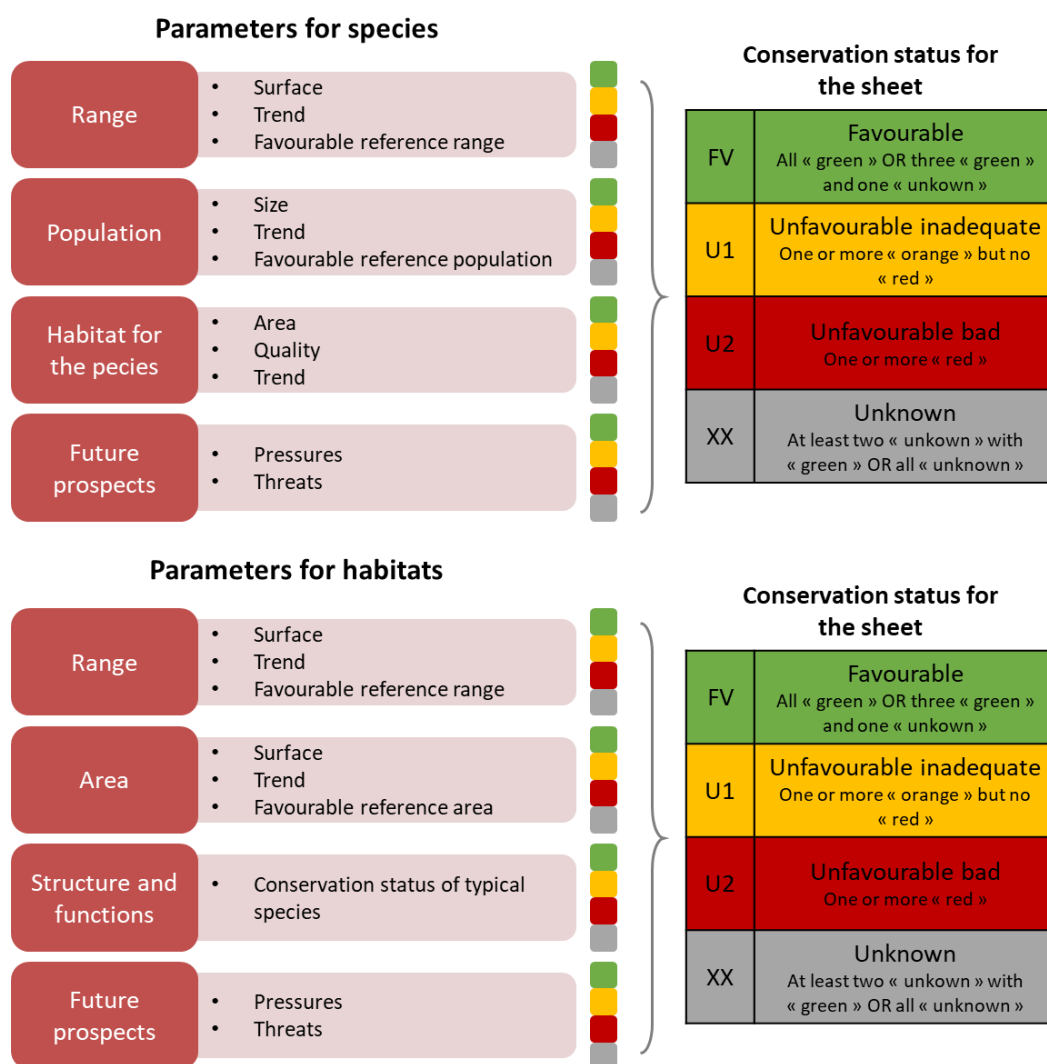


Figure 37 Conservation status assessment method in the habitats directive (source: MNHN)

The connection between conservation status at the species level and the NNL seems, wrongly, to be a matter of common sense: if all the individual impacts are effectively reduced to zero net loss, conservation status should be maintained. However, this sidesteps the question of the scope of EIAs (small projects, even though they are in the majority, are not subject to them), and lends itself to poor consideration of the cumulative impacts of several projects. Their spatial arrangement can lead to the

disappearance of local populations close to development projects without being present on the plots directly impacted (small populations trapped in blocks, for example).

The preservation thresholds used for impact assessments on protected species and habitats are simple, as the objective specified by the law is No net loss of biodiversity. The threshold therefore corresponds to the value of the initial state.

We have seen what metrics could be used to represent built-up areas and protected species and habitats. A secondary question that we have not yet clearly asked is: what is the relationship between these two frameworks (and therefore these two capitals)? Do they overlap? And therefore, potentially, can double counting occur?

2.3. The link between "no net land-take" and environmental impact assessments

The NNLT policy and the AMRO sequence do not fit together perfectly. They are not legally linked. In practice, ZAN is essentially a national objective that affects companies indirectly, whereas impact assessments are direct obligations, themselves linked to other national policies (Protected species and habitats in particular).

Furthermore, while NNLT has national coverage, EIAs cover a much smaller number of projects. A list of projects is given in the appendix to article R122-2. However, most of these projects are required to prepare a minimum file, which will enable the environmental authority to decide whether or not a full EIA is required. In 2015, for example, only 12.5% of the 2,222 dossiers submitted were complete. (Bigard, 2018). In addition, a large proportion of urbanisation and degradation falls completely under the radar of the EIA due to their small size. This is particularly the case for urban development of less than 4 ha with a land area of less than 10 ha, and roads of less than 3 km (other than motorways and expressways). However, half of all land artificialisation comes from small housing projects (Bigard, 2018).

Furthermore, the capital to be preserved (natural, agriculture and forest areas, or species, habitats and protected areas) is not a priori the same in NNLT and in the EIAs. There is no perfect overlap between the two, even if there is a common area. This partial overlap also applies to economic activities (and therefore impacts). This is illustrated in Figure 38 (red bubbles).

As far as the natural entities are concerned, it should be remembered that the protected species and habitats are exclusively natural, and are therefore found in non-impervious areas (they may be present in a residual manner in artificial, but non-impervious, areas). They are only present in part of them. The intersection between the two frameworks is therefore a sub-set of undeveloped areas as defined in the above-mentioned decree. Impacts linked to extractive activities are excluded, as the decree does not consider these activities to be artificial.

In terms of activities, only the creation of industries (ICPE, energy, waste treatment) and major infrastructure projects are common to both frameworks.

All this is summarised in Figure 38. It should also be noted that pollution linked to small-scale projects (housing, roadworks, small-scale industry, etc.; arrow 3) is not taken into account in either framework, nor are all agricultural, forestry and fishing activities (arrow 4).

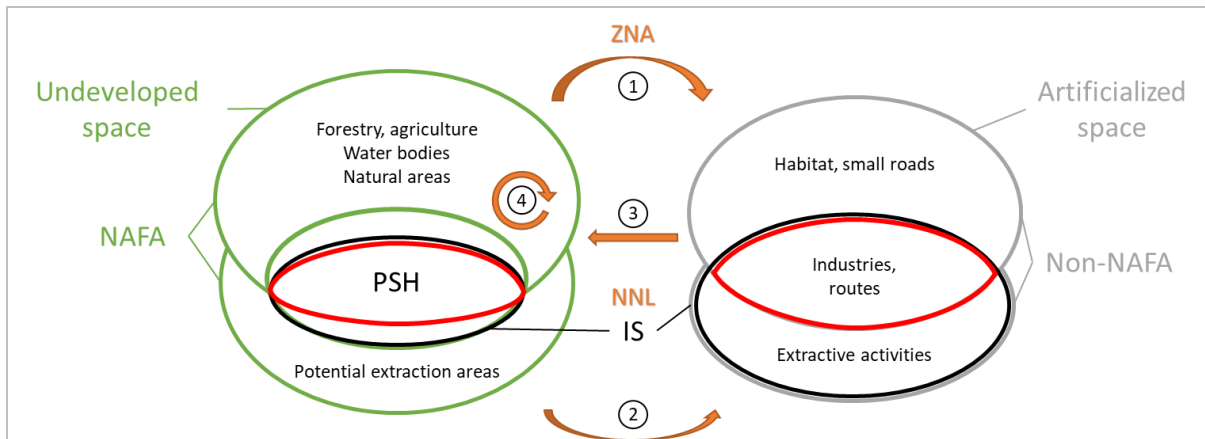


Figure 38 No net land-take and Environmental impact assessment frameworks.

Legend: **NAFA**: Natural, agriculture and forest areas; **PSH**: Protected species and habitats; **NNLT**: No net land-take; **EIA**: Environmental impact assessment; **NNLT**: No net loss. **Green bubbles**: non-impervious habitats; **grey bubbles**: impervious or highly anthropised areas (excluding intensively farmed areas); **black bubbles**: impact assessment perimeters; **red bubbles**: overlap of NNLT and APB. **Arrow 1**: conversion of a non-artificialized area into an artificialized area (subject to the NNLT objective); **arrow 2**: implementation of an extractive activity (not covered by the NNLT); **arrow 3**: deposition of pollution in the NAFAs (certain cases are covered by the NPA); **arrow 4**: degradation of the NAFAs by the activities present in these areas (agricultural intensification, etc.).

This last sub-section shows that attention must be paid to the structure of information systems and the allocation of conservation actions. Some actions may contribute to both NNLT and No net loss of protected species and habitats.

3. Estimates of debts ecological biophysical and monetary

The first part of the chapter identified the ecological entities that can be considered as capital. We can now attempt to estimate the value of the total ecological debt incurred by the French economy. We present the work that has been done in this respect for the capital 'undeveloped areas' and then for the capital 'protected species and habitats'.

3.1. Estimation of a macro debt linked to artificialisation

As we saw above, biophysical ecological debts can be estimated on the basis of two types of reference thresholds: by considering the final objective or by considering a trajectory towards the final objective at the date by which it must be achieved nationally (2050).

As the artificial land cover data stops in 2020, we have estimated the artificial land cover in 2021 using the 2016-2019 trend (pre-Covid). These data come from the artificialisation observatory created by the Climate and Resilience Act and supplied by CEREMA. They come from land registers, which are considered more appropriate than Corine Land Cover, the Terruti-Lucas survey or agricultural surveys (SAFER, Agreste). This is the source with the finest granularity (infraparcels), an annual time step and national coverage. There are, however, a number of borderline cases (notably unregistered plots). Their classification is detailed by CEREMA (CEREMA, 2022b).

The estimated monetary debt is based on a scenario of 100% ecological restoration. The amount of ecological restoration is taken from a France Stratégie study giving a range of costs per square metre (France Stratégie et al., 2019). This range relates to a set of projects that include depollution, desiltation, and the construction of a technosol. Depending on the need and the type of remediation required, costs vary widely. However, desilting is the most expensive. Land acquisition and deconstruction costs are not included. To estimate the ecological debt, we use the high and low values of this range. This gives, symmetrically, high and low values for the ecological debt.

The results are presented in Table 24. It can be seen that choosing the 2050 reduction trajectory as the preservation threshold reduces the amount of ecological debt by a factor of ten. The amount of monetary debt is mechanically reduced by the same factor.

Table 24 Change in ecological debt due to artificialisation in 2021 (source: author, based on CEREMA, 2022a; Fosse et al., 2019)

	Absolute threshold	2050 trajectory threshold
Artificialisation 2021 (km²)	214,5	
Debt (km²)	214,5	19,9
Low monetary debt (€bn)	20,4	1,9
High monetary debt (€bn)	75,1	7,0

The variations in debt in 2021 can be broken down by destination (housing, economic activity, mixed and unknown) using the average rates of artificialisation between 2009 and 2021 (Table 25). The relative rates between the two largest categories (housing and economic activities) are stable over this period. It can be seen that only a quarter of artificialisation comes from economic activities, while two-thirds is linked to housing, and therefore to Households.

For illustrative purposes, we have added to Table 25 the amounts of savings and financing capacity of Households (housing line) and private companies ("economic activity" line) to give relief to the

amounts of variations in ecological debt in 2021. These data come from the 2021 national accounts published by INSEE.

Table 25 Responsibility and ability to recover the ecological debt in 2021 (in billions of euros; source: author, INSEE data, and CEREMA, 2022a)

		Absolute threshold		2050 trajectory threshold		Economic data	
Destination	Rates	Low debt	High debt	Low debt	High debt	Gross savings	Financing capacity
Habitat	67 %	13,7	50,6	1,3	4,7	193,9	119
Economic activity	25 %	5,2	19,0	0,5	1,8	64,9	31,8
Mixed	2 %	0,4	1,5	0,0	0,1	NA	NA
Unknown	5 %	1,1	3,9	0,1	0,4	NA	NA
Total	100 %	20,4	75,1	1,9	7,0		

We can see that the ranges of debt are well below the savings and even the financing capacity of the sectors to which we can attribute the ecological debts when we consider the trajectory up to 2050. On the other hand, if we had to pay off the absolute debt contracted in 2021 in the short term, things would be much more complicated. For Households, between 10% and 42% of their financing capacity would be required. For economic activities, this figure rises to between 16% and 61%.

3.2. Estimated micro-macro debt linked to Environmental impact assessments

With regard to protected species and habitats, a source of biophysical data exists at company level, the impact assessment (EIA). These studies contain valuable information because they are linked to a particular company. This makes it possible to trace impacts back to the institutional unit, i.e. companies, administrations, Households, etc., which are the statistical units used in National accounting. Ecological debts can therefore be attributed to them.

We have therefore carried out specific work on these studies, which have now been compiled in a national database available online at¹⁵⁰. Our aim here is to assess their quality as a statistical source, and we will take a sample to estimate a national debt. We will see that it is not possible to access information on the 1030 "protected species and habitats" capitals individually (which in any case are not all used by the companies in our sample). We will therefore present the results on a more aggregated basis.

3.2.1. Sampling, ecological variables and measurement costs reduction and offset

We have taken as our sample population the EIAs submitted after 1^{er} January 2018, the date on which the complete file was uploaded to the "projet-environnement.gouv" platform. We thus retained 903 EIAs out of a total of 8456 files mentioned. We then stratified the sample according to the nature of the projects, as indicated in the national database. This field is close to the categories of the INSEE's Nomenclature des activités françaises (NAF), which made it easier to provide information, but also ensured a degree of homogeneity between projects in the same category. To limit the number of EIAs to be considered, we chose a region where the number of EIAs per category is, in proportion, similar to that for France as a whole. This gives a relatively robust result for this region, and allows us to extrapolate the results to the rest of France. The Auvergne-Rhône-Alpes region meets this criterion.

¹⁵⁰ <https://www.projets-environnement.gouv.fr/pages/home/>

The 111 EIAs in this region are therefore the sub-population from which we drew 36 EIAs at random, respecting the proportion of each category in the total. The nature of the EIAs sampled is shown in Table 26. As regards the dates on which the EIAs were added to the database, 13 were added in 2019, 11 in 2020 and 11 in 2021¹⁵¹.

Table 26 Stratified sample of Environmental impact assessments

Type of project	N	Relative prop.	Sample size	ARA failure rate	National default rate
Installations classified for the protection of the environment	478	52,9 %	21	35 %	4 %
Solar power generation facilities	159	17,6 %	7	50 %	4 %
Building and development works	114	12,6 %	5	38 %	4 %
Road infrastructure	36	4 %	2	22 %	6 %
Deep wells, in particular geothermal wells, wells for water supply, with the exception of wells to study soil stability	14	1,6 %	1	50 %	7 %
Other (27 different categories)	102	11,3 %	0	NA	NA
Total	903	100 %	36		

Legend: N: total number of EIAs in the national population selected. Relative prop.: proportion of each category of EIA in relation to the others, in order to construct the stratified sample. ARA sampling rate: proportion of EIAs in Auvergne-Rhône-Alpes in this category that were sampled. National sample rate: proportion of national EIAs in this category that were sampled.

As we saw earlier, the indicators used to quantify the impacts and status of protected species and habitats are not harmonised and are not the conservation status classes defined in the nature directives. For our work on the EIAs, we therefore had to define substitute variables with a new unit to qualify the status and level of impact on capital in a harmonised way for all the EIAs. We thus described the state of the capital (and therefore the ecological impacts) in qualitative terms, with 6 classes (intact, virtually intact, degraded, moderately degraded, severely degraded, very severely degraded). This status is established by expert opinion on the basis of the impacts identified in the EIAs. The ecological debt is defined as the difference between the initial state and the post-project impacts estimated in the EIA.

Following this, we listed the reduction and compensation measures and indicated the amount of expenditure planned for each of them. Given that, by definition, avoidance does not give rise to expenditure but to opportunity costs, we have not considered them in our study. Some measures (including avoidance) were not correctly assigned to the correct category in the EIAs, requiring manual reclassification. The cost estimates (total and annualised) are based on the values given in the EIA. The EIAs mention the total ecological gain with AMRO measures. We have included this in the database, applying a correction if avoidance measures are included. This makes it possible to estimate the ecological gain associated with the actions planned to repay the debt.

Compiling the data for an EIA took an average of one hour and twenty minutes. The quality of the data varied, with some being well structured and directly containing the information sought, while others did not follow the framework established in 2018 to harmonise EIAs.

¹⁵¹ Assuming that there has been no significant change in the variables over this three-year period, we can consider that the extrapolation work we carry out below is valid for each of the years.

3.2.2. Results

Within the 36 EIAs, we identified 103 capitals impacted by the projects. Three EIAs did not include a section on the environment, due to the lack of impact in this area.

The EIAs studied were able to provide information on the variables of interest with a satisfactory rate for ecological debts (87% could be quantified) and for reduction and compensation measures (94% provided information or mentioned the absence of measures). The budgeting of measures is rarer: 36% of the EIAs provide at least a monetary value. Five EIAs (for one capital in each case) provided for both reduction and compensation measures. The completeness rate for the most important variables is shown in Table 27.

Table 27 Rate of completion of impact assessment variables

Variables	Existing information	
Project identifier	106	100 %
Type of project	106	100 %
Project duration	60	57 %
Opinion of the Environmental Authority (WA) on the project	60	57 %
General comments on the project	96	91 %
WA opinion on the capital in question	38	36 %
Type of capital	103	97 %
Concern for preservation	100	94 %
Initial state	92	87 %
Estimated post-project status	92	87 %
Ecological debt (biophysical)	92	87 %
Reduction measures ¹⁵²	100	94 %
Budgeted reduction expenditure	22	21 %
Compensation measures ¹⁵³	103	97 %
Budgeted compensation expenditure	24	23 %
Total reduction and offset expenditure	38	36 %
Estimated ecological gain from measures reduction and offset	88	83 %

The biophysical debts estimated in the EIAs are summarised in Table 28 and in Table 29. For the first table, we adopt the structure of a national account, which lists the liabilities on the right, and sets off the corresponding values against each other. This is a purely biophysical table. The monetary values were often estimated for the project as a whole. It was therefore not possible to break them down by type of capital. The unit used is the number of ecological status classes that need to be improved.

¹⁵² 58 values correspond to "no reduction measure".

¹⁵³ 54 values correspond to "no compensation measure".

Table 28 Environmental liabilities in the sample

Non-financial companies		Liabilities
211,5		SPECIES
	54	Birdlife
	36,5	Chiropterans
	36,5	Entomofauna
	12	Flore
	49	Herpetofauna
	23,5	Mammals other than chiropterans
4		HABITAT
	4	Habitat
215,5		Total

Table 29 shows the same data in a different form. The debts are broken down by NAF category of company and we add more variables to give a more precise idea of the data set. It can be seen that the average debt per capital is zero (0) to moderate (3). The average ecological rate of return is 53%. The measures planned for 23 of the capital would lead to ecological neutrality. This means that these measures are well calibrated to pay off the ecological debt. For 65 capitals, on the other hand, the measures are insufficient to pay off the ecological debt. There remains a residual ecological loss. However, the State considers that this loss is acceptable if it is small, which is the case for most of the EIAs. This means that the government accepts that part of the debt should be written off. On the other hand, three EIAs mentioned a significant loss. In these three cases, the WA's opinion states that the measures should be reviewed and clarified.

Table 29 Breakdown of biophysical debt by sector

	Number of capitals	Average debt	Total debt	Total expected ecological gain	Average ecological gain
ICPE	52	2,6	113,5	63	58 %
Head office activities	3	0	0	0	0 %
Public administration	1	3	3	2	67 %
Collection of non-hazardous waste	5	3,1	15,5	15,5	100 %
Wholesale of ores and metals	5	2,8	11	11	100 %
Gravel and sand pits, extraction	14	2,8	37	15	47 %
Cement manufacture	10	2,6	23	10	42 %
Manufacture of paper and cardboard	3	2,0	4	1	25 %
Electricity generation	2	2,0	4	1	25 %
Office property development	1	2,0	2	0	0 %
Fruit processing and preservation	1	0	0	0	0 %
Routine earthworks	7	2,0	14	7,5	57 %
Electricity generation facilities (solar)	27	2,1	56,5	26	42 %
Electricity distribution	4	1,5	6	3	39 %
Engineering, technical studies	3	2,2	6,5	1,5	18 %
Electricity generation	20	2,2	44	21,5	46 %
Building and development works	13	2,2	19,5	17	89 %
Architectural activities	1	2,5	2,5	0,5	20 %
Activities of real estate agents	3	0	0	0	0 %
Public administration	8	2,1	17	16,5	98 %
Aluminium metallurgy	1	0	0	0	0 %
Road infrastructure	9	2,9	26	9	29 %
Public administration	9	2,9	26	9	29 %
Deep drilling	1	0	0	0	0 %
Water collection, treatment and distribution	1	0	0	0	0 %
Grand total	102	2,4	215,5	115	53 %

For illustrative purposes, we can also look at the amounts spent in relation to the expected ecological gain (Figure 39). It is difficult to generalise these amounts because of the small number of EIAs in each category (reduction alone: 17, offset alone: 19, reduction+offset: 4). They do, however, give an order of magnitude that can be used as a benchmark for comparison with larger samples.



Figure 39 Average reduction and offset expenditure per expected ecological gain (source: authors)

Reading: on average, it is necessary to spend €180,000 (light blue) on offsetting alone to obtain an ecological gain of between 0 and 1. This amount rises to €33,000 (navy blue) if offsetting is combined with reduction.

Based on the sampling data, it is possible to estimate the ecological debt for the region and for France (Table 30). To do this, we extrapolated the sample from the number of EIAs. The values of biophysical debt (qualitative) and ecological gain are difficult to interpret beyond the project level. On the other hand, if the budgets forecast in the EIAs and the extrapolation are robust, the forecast monetary values make sense on the scale of the region and France.

Table 30 Estimated ecological debt for Auvergne-Rhône-Alpes and France as a whole

	Number of EIAs	Biophysical ecological debt	Expected environmental benefits	Ecological debt to be settled (total)	Ecological debt to be settled (annualised)
Sample	36	215,5	115	2 344 725 €	567 041 €
ARA Region	111	664	355	7 229 569 €	1 748 375 €
France as a whole	903	5405	2885	58 813 519 €	14 223 266 €

The amounts to be settled by project sponsors in Auvergne-Rhône-Alpes are therefore €7.2 million. As some of this expenditure is planned over 20 or 30 years, these figures can be annualised. The annual debt would then be €1.7 million. The values for France as a whole are automatically higher: almost €59 million in total, or €14 million per year.

This part has made it possible to estimate the ecological debts linked to artificialisation and impacts on protected species and habitats. In order to build up a complete set of accounts, it is then necessary to identify the expenditure actually incurred to preserve this capital. This makes it possible to determine the extent to which the debts have been repaid¹⁵⁴. This is the subject of the next section.

¹⁵⁴ It should be remembered that the estimates we have made have different timeframes. The debt for NNLT is estimated at the end of the period (end of 2021). In contrast, the information in the EIAs is based on pre-project budgets that can be linked to the start of the period (even though the data relates to 2018-2021, we can assume that there is no annual variation, and therefore that it corresponds to the start of 2021). In principle, the amount

3.3. Estimated expenditure actually incurred to settle debts

The Environmental Protection Expenditure Account, a satellite of the National accounting system, shows the financial effort made by businesses, Households and public authorities to protect the environment. The account gathers information by major environmental domain (soil, air, biosphere, etc.) and by pressure on the environment (pollution, noise, etc.). We are interested here in the sub-account on biodiversity and landscapes. The Service de la donnée et des études statistiques (SDES; attached to the *ministère de la Transition écologique*) relies on various sources of data to construct it. In particular, it uses data from the Water Agencies, INSEE, the General Directorate of Public Finance (Ministry of the Economy and Finance), the National Forestry Office and the Regional Directorates for the Environment, Planning and Housing (DREAL).

In relation to the ecological debt, this expenditure is that which is actually made to pay off the debt. We have had access to detailed expenditure data in order to extract those that are closest to the capital we wish to study. The aim of the work that follows is to estimate the amount that actually reduces the stock of debt. We separate the analysis of artificialisation and protected species and habitats.

The SDES data relate to 2018. The orders of magnitude of spending change little from one year to the next: between 2018 and 2019, current spending on biodiversity rose from €853 million to €905 million, and investment from €202 million to €210 million. So the time lag with the data on artificialisation and protected species and habitats is not particularly troublesome for our illustration. However, this should be corrected in time.

The database presents environmental expenditure¹⁵⁵ according to: the account to which they are attached; the environmental field of the expenditure; the corresponding National accounting aggregates¹⁵⁶; the nature of the operation; the project sponsor making the expenditure¹⁵⁷; the annualised amounts spent since 2000.

There is no direct account for artificialisation or for protected species and habitats alone. We have therefore extracted expenditure by destination (Table 31). We began by selecting current expenditure (Intermediate consumption and Consumption of fixed capital) and investments.

Secondly, we have excluded certain environmental fields: "Knowledge of natural heritage and its evolution", "Monitoring measurement networks", "Combating erosion and other physical degradation", "Prevention of infiltration of polluting substances", "Protection of maritime and coastal areas". This allows us to keep three of them: "Remediation of polluted sites and soils", "Protection of biodiversity" and "Protection of natural land areas and landscapes".

For NNLT, we have selected expenditure relating to the remediation of polluted sites and soils. This includes preparatory studies. Site remediation is a difficult category to deal with, as it may involve both

of expenditure actually incurred to repay the debt should be compared with the amount of debt discounted at the end of the period.

¹⁵⁵ The various variables are not systematically entered for each item of expenditure.

¹⁵⁶ The categories are: "Current expenditure (excluding CFC)", "Consumption of fixed capital (CFC)", "Current expenditure", "Capital expenditure", "Production", "Transfers paid", "Transfers received".

¹⁵⁷ The classic sectors of National accounting: "General Government", "Non-Financial Corporations", "Households".

simple desartificialisation and ecological engineering expenditure. In the absence of detailed information, we have attributed half of the amounts in the SDES account to artificialisation.

For protected species and habitats, we have selected only private expenditure. General Government is also subject to EIA, but it is impossible to separate spending on development projects from spending on their public service mission (which can be likened, not to spending to pay off a debt, but to producing an environmental good for citizens). We have therefore selected all the motorway companies' expenditure on protecting sites, landscapes and biodiversity. The other half of the industry's expenditure on protecting biodiversity and restoring sites is taken into account here. Work on wetlands is not necessarily triggered by offsetting for PSH, but as we are unable to distinguish what does and does not come under this heading, we include the total amount.

Table 31 Selected data from the expenditure account for biodiversity and landscapes (in millions of euros)

	GG	Companies	Total
Remediation of polluted sites and soils	306 €	558 €	864 €
Studies with a view to decontamination work at SSP	64 €	169 €	233 €
Specific investments for decontamination activities SSP		95 €	95 €
Remediation work at SSP	242 €	294 €	536 €
Protecting biodiversity	192 €	28 €	219 €
Communes and EPCIs (GFPs and union structures): preserving the natural environment	136 €		136 €
Départements: preserving the natural environment	56 €		56 €
Protecting biodiversity and rehabilitating sites (industry sector)		28 €	28 €
Protecting natural land areas and landscapes	775 €	440 €	1 175 €
Communes and EPCIs (GFPs and union structures): preserving the natural environment	91 €		91 €
Départements: preserving the natural environment	168 €		168 €
Tasks of the Conservatoires d'Espaces Naturels (CREN)	56 €		56 €
Site and landscape conservation policy	16 €		16 €
Protection of sites, landscapes and biodiversity (motorway concession companies)		57 €	57 €
Protecting biodiversity and rehabilitating sites (industry sector)		279 €	279 €
Restoration and management of aquatic environments (including wetlands)	405 €	104 €	508 €
Grand total	1 161 €	1 026 €	2 259 €

Legend: red boxes: expenditure attributed to desartificialisation; green boxes: expenditure attributed to protected species and habitats; mixed boxes: expenditure attributed half to each capital.

In 2018, total expenditure on desartificialisation amounted to **€1.017 billion**. Expenditure on protected species and habitats totalled **€314 million**.

3.4. Sequence of accounts including ecological debt

The values of ecological debt and environmental expenditure can be brought together in an extended Sequence of accounts (or Sequence of accounts) following the logic of the CARE model. We have done this for the artificialisation of natural areas (Table 32), but not for 'Protected species and habitats' (PSH).

This capital lends itself better to such an exercise than the PSH, because the values of the debt (we take the value of 7 billion for our illustration) and of the expenditure to pay it off (1 billion) are orders of magnitude consistent with the fact that artificialisation is increasing. For PSHs, the estimated debt of €14 million is not consistent with the value of expenditure taken from the SDES account (€314 million). Neither the relative values nor the orders of magnitude appear to be appropriate in view of the deterioration in the state of conservation of PSHs observed in the reports for the nature directives (birds and habitats, fauna, flora). The quality of the EIAs is certainly to blame, although we do not know to what extent. Furthermore, the cumulative impacts of projects play a very important role in the degradation of natural environments and species. However, they are very poorly considered in the EIAs (Bigard, 2018)..

The Sequence of accounts (SOA), which we described in detail in Chapter 2, is made up of flow accounts (current accounts and changes in assets) and stock accounts (assets accounts). Given that we are taking 2021 as the creation date for ecological debt, the change in assets accounts for ecological debt are identical to those for stocks. There is therefore no need to present the latter.

Only two institutional sectors are represented here: construction and nature. Construction is not a real institutional sector, but a branch of activity usually represented in the Input-output tables (IOT), which is the other main table in the National accounting system. Strictly speaking, the sector-industry transition requires a great deal of data processing. We have greatly simplified it for this illustration. We have directly inserted into the SOA the amounts of the IOT 2021 aggregates published by the INSEE. Only cash and deposits (the equivalent of bank accounts) have been arbitrarily estimated, while maintaining an order of magnitude consistent with the other figures.

With regard to the accounting innovations linked to the environment, we invite the reader to refer to chapter 4 to understand the translation of the CARE model, which is designed to comply with the principles of National accounting. Here, we will only provide some keys for reading the table.

The nature sector is a new institutional sector that brings together what the CARE model calls the representatives of natural capital (NGOs, public authorities or scientists depending on the capital) (Rambaud, 2015; Richard, 2012b). They are supposed to guarantee the definition of (scientific) capital and to convey the concern for preservation (and therefore demand repayment of debts).

The main innovation is the creation of a natural capital account, which brings together specific assets and liabilities. The first part of the account records assets corresponding to the (a priori physical) use of natural entities. They are recorded according to rules similar to those of the traditional capital account. These assets are defined in the CARE model and in Chapter 4, and correspond to the way in which capital is used. The second half corresponds to assets and liabilities which are commitments. They function like their equivalents in the financial account.

Table 32 Simplified extension of the Sequence of accounts with the ecological debts linked to artificialisation

CURRENT ACCOUNTS						
Uses	Construction	Nature		Nature	Construction	Resources
Production account						
					323	Production
Intermediate consumption	198					
Preservation activities	1					
GDP	125					
Consumption of fixed capital						
On non-financial assets	9					
On natural assets	0,2					
NDP	106					
					1	Preservation activities
Operating account						
					125	GDP
Compensation of employees	80					
Taxes less subsidies	10					
Op. surplus / Mixed income	34					
Allocation of primary income account						
Secondary income distribution account						
Use of income account						
Savings	34					
CHANGES IN ASSETS						
Change in assets	Construction	Nature		Nature	Construction	Change in liabilities
Capital account						
					34	Savings
Gross fixed capital formation	10					
Consumption of fixed capital	-9					
Net lending (+) or borrowing (-)	14					
Natural capital						
Gross fixed capital formation						
Artificial space	7					
Consumption of fixed capital						
Artificial space	-0,2					
Ecological debt – undev. space		7 -1			7 -1	Ecological debt – und. space
Financial account						
Total net flows of financial assets						Total net cash flows from financial liabilities
Monetary gold and special drawing rights						Monetary gold and special drawing rights
Cash and deposits	6 -1					Cash and deposits
Credits						Credits
Shares and units in investment funds				7 -1		Shares and units in investment funds
Other changes in volume and adjustments						
Revaluations						

Legend: in black, the values published by INSEE; in green, blue and red, the counts and values estimated in this chapter (the blue and red colours show the double/quadruple part). EnA: undeveloped area.

To understand this table, we can present things by describing the operations in chronological order. At the beginning of the year, companies estimate the ecological debts they will incur, firstly from a biophysical point of view, and then translate this into a monetary amount of expenditure to be made to settle the biophysical debt in the end. We then record this amount (7 billion here) as a liability for

the construction sector. In order to comply with the double entry system¹⁵⁸, we need to make an entry on the asset side, as we would for the counterpart of a monetary debt. In this case, the use of natural capital corresponds to the artificialisation of previously undeveloped land. The notion of artificialised space reflects the two ideas at the heart of the notion of asset: the idea of impact and benefit for the business model of the company that creates it. The counterpart of the debt therefore appears in the Gross fixed capital formation (investment) account.

On the side of the nature sector, the sector with which the transaction takes place, a receivable is recorded (which is in the ecological debt account, but on the asset side, not the liability side). Here we consider a treatment similar to that of a central bank, generating an offsetting entry on the liabilities side of the "Other equity investments" sub-account, in the "Shares and units in investment funds" account (United Nations et al., 2011, para. 13.74).

As with any asset that wears out, we have entered a Consumption of fixed capital. We have estimated this by assuming that the assets depreciate over a period of thirty years, giving a figure of 233 million euros per year.

Preservation expenditure leads to two distinct operations. Once the soil decontamination and restoration operations have been carried out, we record the classic financial movements corresponding to a use (in Business accounting, a disbursed expense). That said, in this table we have identified preservation activities, which are still an integral part of Intermediate consumption. In the CARE model, preservation expenditure is not involved in production and is therefore not part of the company's operating cycle. As a result, they must be separated out for special analysis. Since these activities generate income in the economy, and are the result of production in dedicated sectors (ecological engineering, etc.), they contribute to GDP. There is therefore no reason to reduce this expenditure, contrary to what has been proposed by certain authors who have created the concept of defensive expenditure (Ahmad et al., 1989; Stiglitz et al., 2009a).

The second operation relating to preservation expenditure takes place (at company level) when the ecological gain is established. If it is equal to what was estimated, the biophysical and monetary debts are reduced by the corresponding amount (otherwise, only a fraction is deducted). The four entries are as follows: a resource is generated in the construction sector, the counterpart of which reduces the monetary debt; the amount of the claim held by nature is reduced by the same amount, as is the liability it had in counterpart. We have used the figure of 1 billion here.

This table compares the amount of debt accumulated with the expenditure incurred to repay it. This provides a valuable indication for monitoring the ecological transition. Indeed, if the debt is only increasing (in volume), there is every reason to believe that the economy is not on a transition path. To know whether the current state is sustainable or not, we need to be able to interpret the stock of debt, preferably biophysical. The advantage of our accounting approach is precisely that it allows such an integrated analysis (biophysical and monetary, stock and flow).

The user of this table can then compare the debt with the sector's savings and financing capacity. This shows whether the sector's business model allows it to meet these obligations, and to what extent. In our example, it seems possible. If we had taken the absolute preservation threshold and not the one

¹⁵⁸ National accounting is not constructed by statisticians by recording transactions in the same way as business accounting: each box in the table is evaluated more or less independently, sometimes using different sources that have to be reconciled. We present the transactions in quadruplicate to check the consistency of our approach.

resulting from the trajectory to 2050, the sector would not have been able to repay the new debts contracted in 2021 (75 billion). This is an important warning signal. It is doubtful that the sector's future revenues will increase sufficiently to bridge a gap as large as €60 billion.

4. Discussion

This chapter was an opportunity to select ecological entities that could become book capital, i.e. entities to be preserved that would appear on the liabilities side of a CARE accounting system and therefore on the National accounting side. We have identified protected species and habitats, as well as undeveloped areas. The legal frameworks that define them lend themselves to this (they are protected, but there are clearly defined frameworks for derogations) and metrics are defined for them.

We then used various sources of data to attempt to quantify the biophysical and monetary ecological debts. We were thus able to estimate the order of magnitude of the cost of achieving No Net Land-take. Estimating the ecological debt associated with protected species and habitats on the basis of impact assessments proved more difficult. It is not certain that the amounts obtained are reliable. But it was an opportunity to take stock of certain aspects of the quality of this potential data.

Finally, we have extracted some of the expenditure actually incurred in desertifying areas. This has enabled us to illustrate what the extended national accounts sequence could look like.

In this discussion, we will answer the three research questions we posed in the introduction.

4.1. Review of certain accounting policies adopted

4.1.1. What capital should be included or excluded? Assets and forest clearance

French national accounting seems to be the only one to use the terms "comptes de patrimoine" or "mesure du patrimoine" when referring to assets and liabilities. The international community uses the terms "*balance sheet*" to describe the accounts, or "*measure of wealth*" when referring to what the accounts seek to measure (Vanoli, 2002, p. 443). But with the term patrimoine, the French "had in mind that it could cover a broader notion than that of wealth, if by the latter was meant a set of assets necessarily estimated in monetary value" (Vanoli, 2002, p. 443). This is how the environment came to be included in natural heritage accounts (Commission interministérielle des comptes du patrimoine naturel et al., 1986) in the full knowledge that not everything would be monetised. Cultural heritage could also have been the subject of accounts in their minds, part of which would only have been quantified in physical terms (Vanoli, 2002, p. 443). The notion of heritage therefore has a certain anchoring in NA, which merits a closer look.

This notion is used recurrently in the environmental field (for a quick review of the English and French etymology of the term patrimoine, see the Appendix H). Franck-Dominique Vivien (in Barrère et al., 2005) describes the parallels or explicit conceptions of the environment as heritage. He considers the extended meaning, including past origin, the need to pass it on, the extension of possession beyond the individual and without this necessarily covering monetisable goods. He cites the following examples: in forest management, the creation of the "green museum" in the forest of Fontainebleau; in the 1972 Stockholm Declaration, which speaks of nothing other than heritage; in the emergence of the notion of the "common heritage of mankind" (with varying degrees of success); in the protection of natural and cultural heritage by UNESCO; and then, back in France, in natural heritage accounts and the creation of regional nature parks.

The concept of natural heritage can be found in article 1 of the 1976 law (Commission interministérielle des comptes du patrimoine naturel et al., 1986). The French Environment Code also refers to it:

"Spaces, resources and natural environments on land and at sea, the sounds and smells that characterise them, sites, day and night landscapes, air quality, water quality, living beings and

biodiversity are part of the nation's common heritage. This heritage generates ecosystem services and use values". (article L110-1)

Then, further on, under the title of natural heritage inventory:

"The natural heritage inventory is instituted for the whole of the national land, river and marine territory. An inventory of natural heritage means an inventory of ecological, faunistic, floristic, geological, pedological, mineralogical and palaeontological resources". (article L411-1 A)

The concept is therefore very broad, and consequently lacks substance. Indeed, it does not seem reasonable to want to pass on to future generations all of the elements mentioned intact. Finally, if this heritage is to have a legal reality, the Code only really creates one in the context of regulations, for example on protected species and habitats, emblematic and protected sites, etc., which we discuss in this chapter. In order to find a more precise content for this notion of heritage, it seems to us that a more systematic exegesis of the Environment Code is required.

In connection with the CARE model and our work, the qualification of environmental entities as assets could be a signal, an indication, that there is a significant concern for preservation, and therefore that the creation of a liability is possible, and possibly expected. However, for this to happen, the term heritage would have to be better defined in law (in particular, it would have to be extended beyond the individual) and, ideally, an explicit connection would have to be made with the notion of ecological debt.

We have seen in this chapter that forest clearance is one of the grounds for triggering an environmental impact assessment. The question therefore arises of including forests as capital to be preserved, using an indicator of forest area. A brief overview of forestry law provides some answers. The purpose of the 1827 Forestry Code was to "reconstitute and protect the national forest heritage", at a time when French forests were in a very poor state. The forest minimum was reached in 1820, which led to catastrophic flooding in particular (Barrère et al., 2005). The policy of restoring mountain land was one of the responses. At the time, forests were the focus of particular attention. However, the notion of heritage has disappeared from the current forestry code. This seems to be the result of amendments to the code in the 1980s and 1990s. At that time, and for several decades, the forest had been gaining a lot of surface area as a result of rural abandonment and the increase in agricultural yields. It seems that the forest's status changed in response to the disappearance of the major causes of its degradation (overexploitation and land clearance).

These factors suggest that forests should not be considered as capital, at least not in terms of a surface area indicator. If we look at the state of the forest from other angles (its diversity, the state of health of the stands, etc.), the question of its inclusion arises much more clearly. Moreover, 68 forest habitats are protected, which clearly shows that some forests are subject to conservation concerns.

On the other hand, a "French forest" entity, translated by a surface area indicator, does not seem to have any place today in the management of ecological debts through accounting. And it will not be considered that a request for authorisation under the Forestry Code is sufficient to record forest areas to be cleared as a liability. This is consistent with the fact that the application for authorisation relates precisely to the permanent change of use of an area, so that it is no longer used for forestry. There is no going back. Climate change, which poses major, even existential threats for certain types of forest,

may well lead to legal changes that will require all forms of woodland to be reconsidered as entities to be preserved.

4.1.2. What metric for biodiversity?

Based on the notion of biodiversity, it would have been tempting to construct our ecological debts on the basis of biodiversity footprint measurement tools for companies (CDC Biodiversité, 2020; Lammerant et al., 2021) which have been developing rapidly in recent years. Another avenue is that of biophysical indicators derived from scientific ecology. Many of these approaches are based on models on a large geographical scale, so the question of data would not have been a complete obstacle. Why didn't you do it?

A relatively widespread idea in the field of biodiversity indicators for businesses is that we lack a clear and shared metric for assessing biodiversity as a whole, and therefore the impacts and dependencies on it. What is lacking is a tonne of BA equivalent₂ for the climate (CDC Biodiversité, 2017; Lammerant et al., 2021, 2019, 2018)¹⁵⁹. In reality, this idea seems to be based on a misunderstanding of the most structuring European directives in this area.

Firstly, the Birds Directive and the Habitats, Fauna and Flora Directive (DO and DHFF) define precise measures and protocols for protected habitats and species (population size, extinction risk, habitat coverage, range, etc.), aggregated into *conservation status* (favourable, inadequate or poor). Aquatic and marine biodiversity, both ordinary and heritage, is covered by the Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD). They contain indicators on ecosystem functions (such as the trophic chain or pollution), emblematic species and supplying Ecosystem services, grouped together under the concept of *ecological status*. Ecological status thus reflects a wider range of values than conservation status (see chapter 4 on this aspect). These directives give very clear objectives for this set of indicators for each Member State. The objectives are adjusted at regional level to take account of biogeographical and socio-economic contexts. Although the aggregation of sub-dimensions may be questionable from a scientific point of view, good ecological status and good conservation status structure the main biodiversity policies, territorial discussions, plans, information systems, etc., because they have great socio-political legitimacy.

The idea that there is no global biodiversity indicator is in fact based on the observation that there is no shared indicator for a specific area: *ordinary terrestrial biodiversity*. This area is not explicitly covered by any of the four directives mentioned above, unlike the footprint metrics, particularly those using the MSA.km² (CDC Biodiversité, 2017; Lammerant et al., 2021, 2019, 2018)¹⁶⁰. That said, it should be borne in mind that the lists of protected species and habitats were drawn up to provide broad ecological coverage, including ordinary nature (Rouveyrol and Leroy, 2021). The problem lies in the application of the policy, not in the imperfect definition of the entities to be preserved and the indicators. Using footprint metrics would still have been interesting for estimating ecological debts linked to ordinary biodiversity. On the other hand, the functions and heritage dimensions could not have been studied. In fact, these aspects are not explained in these tools¹⁶¹, which prevents them from

¹⁵⁹ "Companies face difficulties in identifying approaches to measuring their biodiversity performance that are on the one hand practical and pragmatic and on the other hand meaningful and relevant." (Lammerant et al., 2021, p. 7)

¹⁶⁰ *Mean species abundance per km²*. This metric corresponds to the surface area of an ecosystem in good condition (compared with a reference condition).

¹⁶¹ This is because the data used is global and highly aggregated, the ecosystem typologies are too generic, and there is no species monitoring. See, for example, the work of CDC Biodiversité (2019, 2017).

being monitored and linked to conservation actions, and therefore to debt amounts. On a more secondary note - but nonetheless important in terms of our normative positioning in relation to strong sustainability - it should be noted that the footprint metrics based on the MSA.km² give the same value for a rich habitat over a small area and a poor habitat over a large area. This means that it allows a substitution between surface area and quality (it also allows this between different types of pressure).

More importantly, biodiversity footprints are not based on a careful selection of dimensions of interest to *society*, but on essentially *scientific* conventions. For example, the European Align project (which federates and synthesises the work collected in Lammerant's publications above) makes the following recommendation: "the factors to be taken into account in the choice of a measurement method are spatial precision, accuracy, responsiveness to change and feasibility of application at scale" (UNEP-WCMC et al., 2022, p. 8). Until a few years ago, this choice was perfectly explained by the purpose of these tools: internal management tools, or voluntary disclosure tools, without necessarily having an official reporting objective. But now that sustainability reporting standards are becoming more clearly defined around the CSRD and the ISSB (see chapter 1), this project proposes to include these metrics. In this new context, the choice of scientific conventions must be interpreted differently. Firstly, it could be due to a (persistent, which would be worrying) lack of understanding of nature directives - which do not "just give objectives" (Lammerant et al., 2005). (Lammerant et al., 2019) -or at least of their importance and of the potential for linking corporate sustainability reports to them. Another hypothesis would be that there is a choice (voluntary? Involuntary and unconscious?) not to link the company with state regulations. Finally, the third hypothesis is that it could stem from a desire to firmly anchor companies in a scientific vision of biodiversity, which is laudable but probably unrealistic in view of the socio-political composition that is necessary to ensure full acceptance of this type of metric (cf. the discussion of Latour's *Politiques de la nature* in chapter 1^{er}).

This ties in with our decision to set aside the various scientific indicators of biodiversity (Shanon and Simpson indices; specific, phylogenetic or functional diversity). In both cases, the dimensions covered are not the subject of socio-political discussions and trade-offs. Today, therefore, they fall under the first phase of Latour's *Politics of Nature* (cf. chapter 1), with perplexity centred around the following questions: what can we do with what is supposedly measured by these metrics? Are we really sure that they reflect what we want? How do these entities interact with the collective already in place?

At this stage, their use can shed more light on areas of nature that are being eroded, as the article by Svartzman et al (2021) by targeting financial players. Or to highlight the need to improve already institutionalised metrics (such as good conservation status). We could even make a link with what is described in chapter 4 (part 3): we could attempt to model (using the economic approach described in that same chapter) the ecological debts corresponding to achieving an objective in MSA.km². The process of constructing the model would give indications as to whether this metric could be used (or not) on a large scale (depending on existing and accessible data), while the results of the model would make it possible to discuss the level of objective to be followed.

In any case, all these metrics cannot afford to short-circuit the composition process and ignore those that already exist and, above all, the other institutions that rely on them (Water Agencies and basin committees, marine protected areas, national protected species action plans, Natura 2000 policy, etc.). The future of these footprint metrics will tell us whether the process will be respected¹⁶². If it is, basing ecological debt on these indicators will certainly be very relevant.

¹⁶² In any case, using the metrics defined for protected species and habitats for all ordinary biodiversity would probably be unmanageable for several reasons: the amount of data to be collected, the definition of several

4.2. The micro-macro joint

This chapter was an opportunity to understand the relationship between the micro (or individual: in this case, companies and the ecological entities with which they interact), macro (national) and what lies between the two (the notions of ecosystem and territory subject to spatial planning). This has enabled us to define 'terrestrial biodiversity' capitals. Our work has identified gaps in the information systems needed to represent and take account of these capitals. In particular, there is as yet no (macro) National accounting system to represent environmental issues. What's more, some of the (meso or micro) data that would be needed are poorly articulated or non-existent. Figure 40 summarises this.

The creation of a national target for artificialisation is based on the creation of an area of equivalence for all natural, agriculture and forest areas (NAFA), which are considered to be spatially interchangeable. The starting point is therefore micro entities, which are standardised by a common name and categorisation. We then create a national objective (macro) for this group. Finally, it is broken down by region and territory through planning documents. Each document is an opportunity to negotiate the efforts to be made in each area and to deal with economic issues, distributional effects, etc. The result is collective management of several of these capitals (NAFA) at a meso level (the PLUi). On this point, it is interesting to note that the Convention Citoyenne pour le Climat (Citizens' Climate Convention), which was behind the proposals for the "Climate and Resilience" law, had set a target for each municipality¹⁶³. The parliamentary review judged this definition to be too rigid in relation to the specific demographic and economic characteristics of the communes.

hundred targets per organisation, etc. Thus, EFRAG's ESRS 4 standard proposes metrics that are already present in the DOs, the DHFF and other general standards (SEEA) or recommendations (Lammerant et al., 2021). However, the choice of metrics remains voluntary, based on alternatives that are cited in the appendix. This is an opportunity to add other measures covering ordinary terrestrial biodiversity in a synthetic manner. However, it would seem essential to coordinate these measures with those of the directives mentioned.

¹⁶³ The BA's final report indicates that over the period 2021-2030, the municipalities could have built up no more than a quarter of what they had built up during the period 2000-2020 (Gonon, 2021).

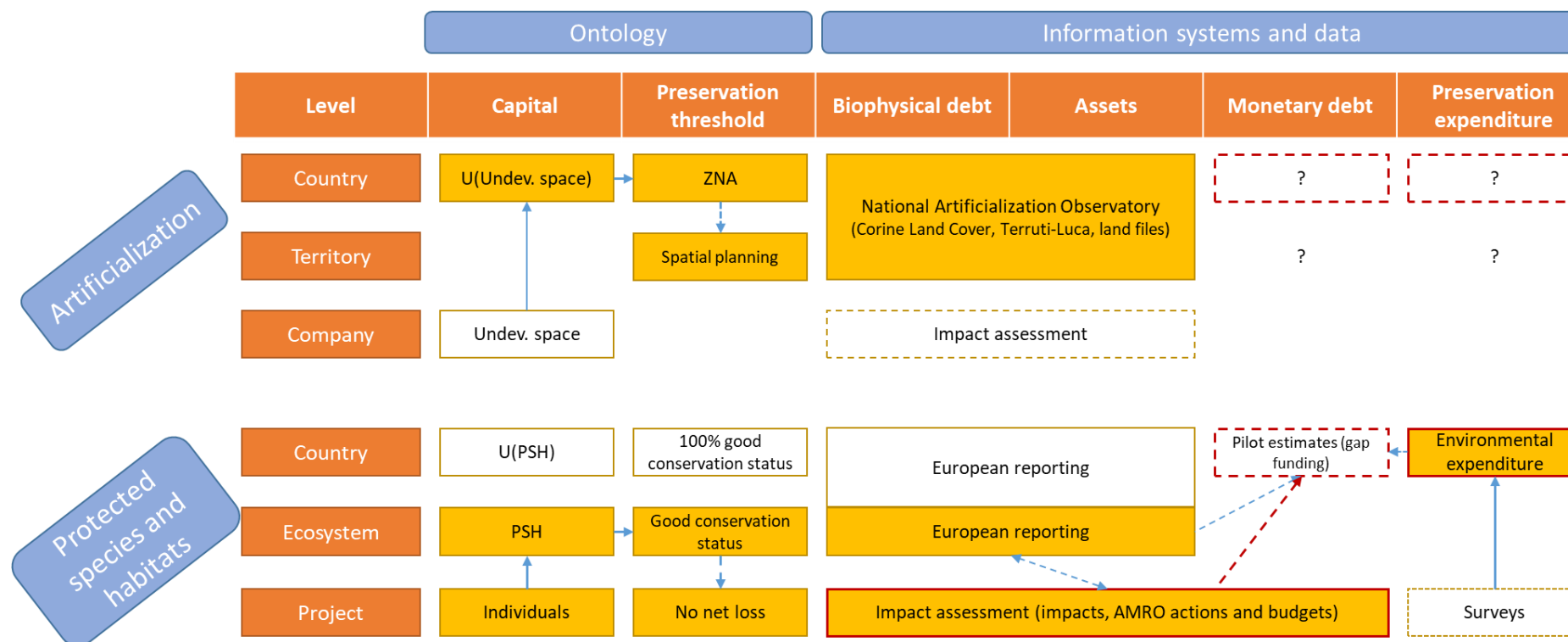


Figure 40 Micro-meso-macro articulation of the existing elements needed to build a National accounting system for ecological debt

Legend: respo.: responsibility; U(EnA): set ("union") of undeveloped areas within the national perimeter; NNLT: no net land-take; U(PSH): set ("union") of nationally protected species and habitats; AMRO: avoid, minimise, restore, offset.

Solid boxes: structuring elements; white boxes: secondary elements to date. Solid borders and arrows: elements stabilised within legal or institutional frameworks; dotted borders and arrows: elements to be defined or in the process of being stabilised. Red borders and arrows: definition, quantification and articulation work undertaken in this chapter.

As far as species and habitats are concerned, the equivalence space has already been created by taxonomists: species and habitat categories, which are groupings of individuals according to ecological or morphological characteristics (Jacob, 1970). Here, species and habitats fall into the meso category because they are impacted by several companies. The objective is defined at species (or habitat) level, which ensures that one species is not offset by another. The companies then receive an impact budget that is directly equal to the actual impact. This is not compensable or negotiable with other players because of the requirement for ecological equivalence and No net loss at the scale of the project or site. At national level, there is no real capital to be preserved. The collection and formatting of data is harmonised because it is the State that draws up the lists of species and habitats and establishes the normative framework that should lead to their preservation. But like all capitals, each ecological entity is far from being the concern of all the economic players in the region. We therefore consider that it essentially comes under the meso level.

We can see that in the case of undeveloped areas and protected species and habitats, the micro-macro link is incomplete. On the other hand, there is some overlap between the two approaches. The species and habitats covered by the nature directives are found in NAFAs, although not necessarily in all NAFAs. In addition, environmental impact assessments apply to highly artificialized sectors.

On this basis, the information frameworks differ quite naturally. There is a national observatory for artificialisation, while there is a strong link with Environmental impact assessments and the individual level. At this stage, there is no official information on the costs of achieving this objective, but this seems to us to be linked to the youth of this policy. Nonetheless, it would be logical for macro- and meso-economic analyses to be carried out to inform the choices made in development plans.

As far as protected species and habitats are concerned, almost all management measures are based on environmental authorisation and the AMRO sequence. In France, the other two main conservation strands are the national action plans (NAPs) for protected species, covering a limited number of particularly emblematic species, and Natura 2000 areas. The AMRO sequence creates a fairly strong management obligation, in principle, but works rather poorly due to prefectural arbitrations that are mostly unfavourable to biodiversity. The connection with the higher level is weak, but would benefit from being more systematically established. This level corresponds to the inventory (or report) that is produced every five years on the state of conservation of PSHs, for the BA¹⁶⁴. The purpose of this data is to provide a general overview of the state of these capitals. However, the data is strictly biophysical and does not include any monetary component. The data includes information on the pressures on these capitals. In this way, we know, by biogeographical area, whether or not the species or habitat is subject to a given pressure (without any qualitative or quantitative estimates of the level of pressure). (Bensettiti and Gazay, 2019; Rouveyrol and Leroy, 2021). It would be relevant to analyse the results of our study (and more generally of all the EIAs) in the light of this information. The gap between the estimates of each approach (meso and micro) would shed light on the additional data to be collected.

The economic and financial aspects are again incomplete, although more advanced than for artificialisation. There is already a satellite national expenditure account for biodiversity and

¹⁶⁴ In France, it involves the botanical conservatories, the Muséum national d'histoire naturelle, the Office français pour la biodiversité and the learned societies for the taxa concerned (herpetology, entomofauna, mammals).

landscapes. But it is poorly connected with the other information frameworks mentioned, as we saw above. Funding requirements for biodiversity are not established regularly, systematically or using rigorous statistical methods. The attempts we have made in this chapter are rather crude and show the extent to which the most basic building blocks are missing. Micro-level data (from EIAs) are promising in principle, but companies still need to be more rigorous in their implementation (particularly with regard to budgeting and forecasting ecological gains). A greater degree of harmonisation and a national database are also necessary. The question of the impact and status metric(s) remains central to aggregating and harmonising the sometimes quite varied field indicators (number of individuals, surface area covered, size of range, qualitative indicators, etc.). It does, however, seem possible to create or re-use metrics from the Habitats, Fauna and Flora Directive or the Birds Directive (conservation status).

4.3. Potential uses of terrestrial biodiversity accounting

We can sketch out here a set of proposed uses for accounting. For this purpose, it is useful to distinguish two levels of use by the public authorities: uses for arbitration between capitals and uses for the management of a given capital. In this way, uses linked to trade-offs in favour of the capital in question can be as follows:

- Ecological debt can be compared with other wealth indicators such as national GDP (which serves as a benchmark for many economic quantities) or with the level of production/income of specific sectors (General Government, impact sectors, etc.). This comparison can be made in two ways: it gives an idea of the contribution of nature (physical and monetary) to economic activity, in the same way as public or private debt; but it also shows what income is available to repay debts, and which debts are prioritised.
- Physical debt can be integrated into national wealth indicator dashboards (such as those created following the Stiglitz, Sen and Fitoussi commissions in France). In particular, this makes it possible to include biophysical dimensions, which are still excluded by the central framework of National accounting.
- Ecological debt corresponds to part of the financing needs to achieve public policy objectives (the difference between past costs and future costs). This is only part of these needs, as the debts only include expenditure on prevention (ex ante) and restoration (ex post). However, the opportunity costs associated with avoidance actions¹⁶⁵ (for example by investing in train season tickets rather than in a fleet of internal combustion vehicles) can be calculated from the analysis of ecological accounts by comparing the biophysical debts attributable to economic assets with those attributable to other assets. The opportunity cost is calculated as the difference between the investment costs.
- The debt can of course be compared with the efforts made today (spending and green activities already in place) to estimate the additional efforts required.
- Debts (and opportunity costs) can be compared with the budgets of other public policies in parliamentary budget discussion processes (green budgets) or at executive level (ministerial arbitration, etc.). One example among many: at European level, this can be used to target the allocation of subsidies to member countries with the highest levels of debt (LIFE, etc.).

¹⁶⁵ Some synonyms are: change of business model (CARE), structural change, etc. (United States Bureau of Economic Analysis, 1995) acquisition of less impactful assets, integrated investments (INSEE IRANTIPOL survey).

- It is possible to compare ecological debts with subsidies that are harmful to biodiversity (i.e. to the sectors impacting the descriptors).

Then, for the management of a capital per se, we can consider whether it is better to avoid the impacts, prevent them or compensate for them or restore the ecosystems ex post. Although it is common to want to tackle problems as far upstream as possible, focusing on avoidance alone is in fact far from self-evident. To take just a few examples: in the absence of functional and economically viable techniques for the capture and geological storage of CO₂, avoidance seems to be the only solution available today for climate capital; today, protected species and habitats and ordinary biodiversity are mainly the subject of ecological compensation (rightly or wrongly¹⁶⁶); the management of terrestrial aquatic environments under the Water Framework Directive combines a range of avoidance, reduction and restoration measures (see next chapter). These choices are therefore the result of a combination of technological possibilities, political choices about the sacrifices to be made (in ecological and economic terms) and the nature of the ecological problem (type of pressure).

Another, related, use is the linking of physical and monetary accounts, which makes it possible to fine-tune actions by targeting those that are most cost-effective. This applies not only to the choice of technique, but also to the players who can (or wish to) take action.

What is the value added of the ecological debt accounting described here compared with existing frameworks? Its main advantage is that it directly links three elements: a biophysical state (stock), an objective and (financial) means of action. This does not yet exist in institutionalised frameworks. One example is the green budget (Bova, 2021; CGEDD and IGF, 2019; OECD, 2021) which is one of the most advanced and innovative initiatives on these points, although it does not go as far as ecological debt accounting. Green budgeting involves classifying all government spending according to its positive or negative impact on the environment. This makes it possible to include the State's general budget in the analysis and thus to go beyond tax incentives or spending specifically targeted at a given environmental area.

However, the green budget still suffers from a number of shortcomings (Gonon, 2021) 1° it does not contain a normative dimension, or even a benchmark for a 'good' level of favourable or unfavourable spending; 2° it is not linked to the spending required, since it only aims to classify spending; 3° it is not compared with the environmental objectives of national climate or biodiversity strategies or legislative frameworks (Hege and Brimont, 2018).

Accounting for ecological debt would introduce the idea of performance (with the notion of ecological solvency) which, thanks to a comparative analysis ("benchmarking"), would make it possible to estimate an acceptable level of expenditure for each category. This would provide a more solid basis for work and arguments on reducing unfavourable expenditure. Today, these are based on the implicit idea that they should all be eliminated. This is unreasonable, however, given that these subsidies and tax benefits were put in place for specific reasons. A more rigorous comparison, within a unified framework, of these reasons with the needs for biodiversity and the distance to the target would certainly shed new light on the trade-offs.

The failure to link the State budget to quantified environmental objectives disconnects one of the State's most important means of action from the targets set for it. In France, for example, I4CE

¹⁶⁶ Some wetlands support it well, due to their good ecological dynamics (Moreno-Mateos et al., 2012) but this cannot be generalised.

distinguishes between favourable spending that contributes to achieving the objectives of the national low-carbon strategy and other so-called favourable spending (cited by Gonon, 2021). That said, it is important to bear in mind what explains the current situation: as these objectives are legislative in nature, they are not subject to the control of the conventionality of the budget exercised by the Constitutional Council. Thus, accounting for ecological debt may lead to changes in governance that go beyond the simple exercise of quantifying the expenditure to be carried out.

Furthermore, the frameworks for derogations for protected species and habitats are currently over-exploited, which means that biodiversity continues to be degraded, albeit within a formal legal framework. This raises the strategic question of the value of accounting in such a situation. Can it worsen the state of biodiversity, or change nothing? Or, on the contrary, can it reformulate debates, or even strengthen the position of environmental players? There is nothing obvious about this question, which needs to be considered in the light of a strategic analysis of environmental management (Mermet, 2011). (Mermet, 2011). This could be the subject of future research.

4.4. The micro-macro link resolves the "modelling vs. observation" controversy

We saw in chapter 3 that cost-based approaches (and therefore ecological debt) were rejected by the SEEA for relatively contingent or ideological reasons, but also for fundamental issues. The methodological proposals for estimating the amounts to be paid were based to a large extent on modelling, which National accounting cannot afford to do (Radermacher, 2020; United Nations et al., 2003)¹⁶⁷. This made sense insofar as these were costs "to be paid", and therefore by definition actions to be taken in the future. In addition, the macroeconomic viewpoint naturally taken by statisticians led them to consider the structural transformations of the economy in order to achieve these objectives: taking into account technological changes, the growth and decline of certain sectors, relative price trends, etc. This was the only way to ensure that these objectives were met.

Dutch economist Rufie Hueting has proposed modelling a green economy by adding an environmental constraint to a general equilibrium model. This makes it possible to estimate the macroeconomic impacts of applying environmental policies (objectives) (Gerlagh et al., 2002; Hueting, 1980). Others, less inclined to include hypotheses on the evolution of prices and technologies, have confined themselves to constructing curves of abatement costs, which are static and purely descriptive (Radermacher et al., 1999). These represented the costs of measures on the x-axis, and the potential for environmental improvement on the y-axis. The intermediate approach consisted of adding a limit to these curves, an environmental objective, and then calculating the sum of the costs of achieving it (the area under the line). The hypotheses materialised if we included in the National accounting the costs to be paid, which would increase final expenditure (Brouwer et al., 1999). Vanoli (2017, 1995) proposed this. The estimate made here to reach NNLT corresponds to this third, intermediate approach, with very simplifying assumptions.

¹⁶⁷ It should be noted that approaches based on damage (by assessing the loss of benefits associated with environmental degradation) were then lumped together. No valid response has yet been given on this point. Within the SEEA, the modelling controversy was set aside around 2005.

On the other hand, the construction of ecological debts based on EIAs departs from everything that has been done or presented within the SEEA on one key point: it is no longer just statisticians who quantify debts, but also companies (the statistical units themselves) upstream of the impacts they wish to achieve. This is what the CARE model proposes, in an even more integrated way.

If it were implemented across the board, costs and debts would not be models external to the economy, but real economic facts that statisticians would observe. Statisticians would thus remain fully in their role if they aggregated the ecological (proto-)debts that we are describing. The assumptions, which are often strong and prescriptive, such as the choice of preservation threshold or transition scenarios¹⁶⁸ (including structural transformations) would no longer be necessary¹⁶⁹. Thresholds are enshrined in law, which is part of the "institutional arrangements" of each economy. This notion is described in the System of national accounts; statisticians respect them because they observe an economy as it is. Statisticians would therefore not have to make these highly political choices. What's more, the scenarios would no longer be based on choices that are difficult to justify from the ivory tower that is INSEE; they would be the fruit of the thinking of companies to meet their obligations.

How are ecological debts based on EIAs economic facts? EIAs are part of the legal obligations of companies, as is compliance with the "avoid, minimise, restore, offset" sequence and the objective of No net loss. The existence of this obligation and the fact that developers are aware of it means that projects can be reconfigured before they see the light of day. Avoidance, particularly spatial avoidance, is a reality observed by government departments (Bigard, 2018; Rouveyrol and Leroy, 2021). Opportunity costs are therefore estimated, quantitatively or otherwise, by project sponsors. The constraint, or potential debt, is therefore internalised in the economic decision-making process. As for reduction and compensation measures, these are of course provisioned for and give rise to real expenditure, in the same way as when a financial debt is repaid. The effects of ecological debt are therefore the same as those of financial debt. Including such ecological debts in the National accounting system would therefore provide a better representation of the economy, because they are already leading to changes in behaviour in an ecological transition that is taking place at a low level.

In addition, the information produced is "audited" by the environmental authority, which issues an opinion on its quality. This opinion informs the decision to authorise the project (the ecological "loan"). What is certainly still lacking is the use of these EIAs by equivalents of financial analysts to inform the decision of other players with regard to the company setting up these projects. Financial solvency is a proxy for risk for investors and lenders. Today, given that the "projet-environnement.gouv" platform has only recently been launched, these players certainly do not need to use it to assess the exposure

¹⁶⁸ One point that remained unclear, but was a source of criticism, was the question of trajectories for achieving targets. Given that we are (and already were at the time of these discussions) in a world far removed from environmental sustainability, the macro players (including the statisticians) asked themselves what trajectories should be followed. But these trajectories are eminently political. Our current proposal would be to take them directly from the national strategies or programming laws that cite them. This may seem to expose the NA to political U-turns, but we see no other solution for the moment. The case of sustainable or "long-term" preservation thresholds seems easier to take up, as they often seem to converge towards the idea of neutrality (carbon, biodiversity, etc.), which is a relatively natural focal point for scientists and society. On the other hand, the trajectories themselves cannot be defined so 'naturally'. During the transition phase towards a sustainable economy, for want of anything better, we will have to rely on the most solid and shared trajectories we can find.

¹⁶⁹ The time horizon for reimbursement, which is sometimes a long way off, still raises the question of how to take account of changes in prices and technologies in the future. As we do not know how this effect is taken into account in National accounting, we will refer this point to future research. A similar treatment could be applied to the revaluation/revaluation of financial debts.

of companies to biodiversity or regulatory risks. On the other hand, during the public consultation phase, the EIAs are mobilised in litigation. For example:

"In the United States, clearing banks form a new economic sector, whose association - the *Ecological Restoration Business Association* (ERBA) - has become the one that generates the most litigation in the courts for non-compliance with the national equivalent of the AMRO sequence". (Levrel, 2020, quoted by Gonon, 2021)

Although it is possible to draw many parallels between the effectiveness of ecological debts and financial debts, we must not lose sight of the fact that the former are not fully respected. Most projects are authorised by the prefect, sometimes despite significant impacts, even after AMRO measures have been taken. Moreover, Gonon (2021) notes that:

"Sanctions for failure to apply AMRO are more administrative than judicial sanctions. (Levrel et al., 2018) although the ecological prejudice recognised in the 2016 law is likely to lead to other forms of litigation. Administrative sanctions can go as far as a formal notice from the prefecture, which is rarely applied in practice (Levrel, 2020). "

The creation of ecological prejudice in the 2016 Biodiversity Act will certainly have an effect in terms of taking these measures more fully into account, but the fact remains that companies are not declared bankrupt if they cannot meet their obligations to the natural environment.

Thus, EIAs and the AMRO sequence are not yet fully ecological debts in the accounting sense, but they are relatively close. Other similar mechanisms exist. Obligations to rehabilitate sites after use, which have existed for a long time in the mining, nuclear and oil sectors (offshore platforms), correspond to ecological debts, even if the full accounting structure presented above is not present (there are no corresponding natural assets). They are already covered by provisions on the liabilities side.

Secondly, the standardisation of sustainability reporting is an opportunity to connect the EIAs, and more broadly the CARE model, with business accounting. The European initiative in this area is particularly interesting. The European Parliament has passed a directive, known as the *Corporate Sustainability Reporting Directive* (CSRD), which establishes the principle of double materiality in this area. Fifty thousand European companies will now be required to publish their environmental impact and the risks and opportunities associated with their activities. The first part corresponds more or less to a generalised *ex-post* impact assessment. The first building blocks of the CSRD implementation standard, published by the *European Financial Reporting Advisory Group* (EFRAG) in November 2022, promise a rigorous approach. The biophysical elements we are looking for are all present: a list of impacted elements, identified by a study of the 'materiality' (significance) of the impacts, the objectives selected and their connection with the relevant national and international objectives, and a list of the policies and actions undertaken and planned to achieve these objectives. There is as yet no integrated accounting structure, nor any monetary valuation of the expenditure required to achieve the objectives. However, the existing structure and the determination of those responsible for this directive and this extra-accounting standard suggest that alignment with the CARE model may be possible in the future.

This point, which consists in a way of rejecting the estimates towards companies so that statisticians do not make them from their overhanging point of view outside the economy, is a first crucial

conceptual advance. To date, we have found only one mention of this idea, without details, in one of the latest articles by Bartelmus (2013) ten years after his departure from the SEEA community. It doesn't seem to have had any echo.

We hope that conceptual advances (the emergence of the AMRO model and our work) and regulatory advances (strengthening of the AMRO sequence and standardisation of sustainability reporting) will breathe new life into this proposal, which could make it possible to take a major step towards institutionalising ecological debts in National accounting.

Chapter 6- National accounting of Seine-Normandy Water Agency's data

1. Introduction

1.1. Presentation of water policy in France

The concept of water as an urban flow, however widespread it may be in the image we generally have of water management, is nonetheless a specific feature of our times. For a long time, water was perceived differently: not necessarily urban and not always a flow of water (Guillerme, 1983 in Narcy and Mermet, 2003). From the 3rd^e to the 8th^e century, it was a defensive and sacred space in fortified cities. From the IX^e to the XIV^e century, water was made more dynamic by channelling and drainage and was used as a source of power in large quantities for crafts (milling, washing, etc.). From the XIV^e to the XVIII^e century, water was stagnant and surrounded towns to protect them over large areas. It was not until the 18th century^e that water was channelled and buried. The expansion of towns and cities led to a new form of water management, necessitated by increased needs that had no comparison with the past. Water was extracted from rivers thanks to the steam engine, and treated thanks to knowledge of bacteriology. The old aqueducts and wells, too few in number or with too low a flow, could not meet the needs of ever larger towns. At first, wastewater was spread out to supplement the sewage system, before treatment plants made it possible to send almost all of it into watercourses.

For Barraqué and Laigneau (2017) modern water management in Germany and the Netherlands is extremely close to the canons of commons management defined by Ostrom. At the level of a hundred or so municipalities, representatives of polluting players (initially only industrialists) and users (citizens), as well as elected representatives, meet to establish discharge thresholds and pool money to invest in treatment facilities or less polluting industries.

In France, application of the polluter-pays principle is in the middle of the road, between Ostrom-style 'community and subsidiary' management and a 'liberal-state coalition' model in which a tax is introduced as an 'incentive to reduce its externality' (Pigouvian tax), but the amount of which is not affected (Barraqué and Laigneau, 2017). The river basin governance body, the *Comités de Bassins*, are sometimes presented as local "water parliaments", even though most of their members are not elected. They involve users, who choose the level of water charges and how they are allocated. Although it was a 1964 law (a national law passed by the French Parliament) that first defined these frameworks for discussion, the role of the State has always been secondary in their operation. Originally, the calculation of water charges, based on the perimeter of catchment areas and a five-year plan with a timeframe specific to water, was completely different from the annuality of the Finance Act and the geographical scope of the tax (the whole country) (Barraqué and Laigneau, 2017)¹⁷⁰.

This community management was reinforced by a measure taken in 1967 at the request of the local authorities. The fee, then included in municipal taxes, was transferred to Households' water bills on the grounds that "it was not the communities that were polluting, but their residents" (Barraqué and Laigneau, 2017). The 1992 Water Act confirmed this. Its preamble refers to water as 'the common heritage of the nation'. Although the reference to Ostrom would be anachronistic (her work only arrived in France shortly afterwards), the point is that the State is 'no longer the master, but only the

¹⁷⁰ Interestingly, this taxation is not a tax in the legal sense, because it is passed on to some users through subsidies (Barraqué and Laigneau, 2017). It is therefore similar to a tax for "services rendered" for these organisations. But the fact that everyone has to pay it (remember that the organisation of water management is harmonised at national level, unlike in Germany, and that citizens and most organisations are subject to this charge) brings it closer to a traditional tax. This intermediate status was confirmed in 1967 by the Conseil d'État, which refused to classify it in either category. Barraqué and Laigneau (2017) explain that this "3^e parafiscal route corresponded to management as a common good".

guardian, and as such must ensure that reasonable use is made of it, by dissociating the right of use from the right of ownership' (Barraqué and Laigneau, 2017). Although the State no longer recognises itself as the master of the resource, it has tried to become the master of the players responsible for managing it. At the end of the 90s, bills and regulations were introduced to create a "high council for public water and sanitation services" with the aim of regulating the sector (Guérin-Schneider and Laigneau, 2017). (Guérin-Schneider, 2011). In the end, all that was created in the mid-2000s was a water police force and a voluntary observatory to monitor service performance.

However, the principle of "water pays for water", which has been in place since the beginning of water policy, has been called into question since the mid-2000s by the State's greater use of the levy and growing demands for biodiversity policy (Barraqué and Laigneau, 2017; Richard and Rieu, 2009). The 2006 Loi sur l'Eau et les Milieux Aquatiques (LEMA) finally placed the vote on water charges on Parliament's agenda, following an opinion of the Constitutional Council in 1982. The consequences of this decision became apparent as early as 2012, when the Ministry of Finance took 10% of the amount to allocate to the State's general budget - previously, all water charges remained in the river basin. The law also introduced a specific division of the fee into sub-categories that we find today: for water pollution, for modernisation of collection networks, for diffuse pollution, for abstraction from water resources, for storage of water during low-water periods, for obstacles in watercourses and for protection of the aquatic environment. The addition of the notion of "aquatic environments" to this same LEMA opened the door to new missions for the newly created water police (ONEMA), financed by the levy. ONEMA, while retaining its policing and expert missions, was merged into the French Biodiversity Agency in 2017 (now the French Office for Biodiversity).

This comes at a time when new challenges are emerging:

"The challenge today is becoming more complicated, because the period when all the investments made were really improving the situation is coming to an end. We need to tackle non-point source pollution, and that means getting farmers on board too". (Barraqué, 2007)

Since the end of the 90s, water stakeholders have had to tackle diffuse agricultural or urban pollution (linked to run-off from impermeable surfaces where the water is loaded with various pollutants). (Narcy and Mermet, 2003). This is because it affects their core business (water purification). In addition, the Water Framework Directive, which concerns the quality of aquatic environments, is coming into force. These players are also choosing to take advantage of areas that can remedy various water-related problems (wetlands, flood expansion zones) at lower cost. This means that those involved in water management need to be in even closer contact with those who already manage these areas: farmers, managers of protected areas, town planners and regional developers. Although not entirely new, a doctrine has been (re)emerging and gaining momentum since the 2000s: "spatial water management" (Narcy and Mermet, 2000). (Narcy and Mermet, 2003).

1.2. Research approach

For this second case study, we take up the three lines of research described at the end of the first chapter, and apply them to water policy.

Throughout the history of water policy, and despite common roots with planning (the main architect of the Water Act was a member of the Water Commission of the Plan; Bouleau et al., 2017) water-related items were not included in the National accounting as we propose. The natural heritage accounts were a highly advanced attempt in their day, but the monetary issue was confined to the

flow of charges (Commission interministérielle des comptes du patrimoine naturel et al., 1986). The international standardisation work on water accounting (SEEA-Eau) also addresses the monetary issue solely from a fiscal perspective (United Nations, 2012). Furthermore, in National accounting (economic), two, sometimes three, sectors are included in national statistics. These are the sectors that bring water into and out of society, because that is what we pay for: catchment and purification take the water from one place; treatment enables wastewater to be discharged in another; and between the two, a public transport service gives businesses, administrations and Households access to it. Ecosystems therefore do not appear.

So, the first issue is as follows: **how can aquatic ecosystems be accounted for in order to equip water policy with a strong sustainability perspective?** This raises several sub-questions: what elements at the heart of water policy would be relevant to highlight? How close are current policy data and frameworks to the idea of ecological debt? What conventions are we going to adopt to do this work?

To address the second question, which relates to the micro-macro link, we need to return to the idea that the structure of the problem to be managed and its representation are closely linked. For example, economic policies are based on a representation of the economy, National accounting, founded on methodological individualism. This is how action is conceived: a government actor collects resources from individuals and directly guides their behaviour through incentives or regulations that apply (almost) indiscriminately to everyone.

On the contrary, as we have seen, water policy is based on a rather different conception of the problem. Water resources, and by extension aquatic environments, cannot be divided up in the same way as industries, markets or institutional sectors. Any abstraction or impact on an environment automatically has repercussions downstream. The connection is considered too strong to be neglected in water management. This is reflected in the institutions set up in France: a form of mutualisation by catchment area, which is akin to management of the common good (Barraqué and Laigneau, 2017). That said, the Water Agencies have a model that is similar in some respects to the action of a State: collecting and redistributing money, negotiating 'micro' objectives (achieving targets for water bodies) with stakeholders or groups of stakeholders.

It should also be noted that the management of water and aquatic environments differs from traditional economic policies in other ways:

- Data is more scattered, there are blind spots in our knowledge of the state and evolution of the environment, and individuals (businesses, General Government and Households) do not keep detailed track of their relationship with the environment.
- It is sometimes extremely difficult, if not impossible, to trace certain relationships between economic activities and the state of aquatic environments (in the case of diffuse pollution), because these environments are complex systems (non-linearity of responses, feedback, etc.).

We can therefore hypothesise that the micro-macro link inherited from National accounting (and described in Chapter 3) will be put to the test by this case study. We can therefore begin by asking what micro-macro links already exist between the objects managed and in terms of information systems. We can then try to understand in more detail how the logic of National accounting (and its link with the individual level) comes into contact with current management logics. This will enable us to sketch out the potential contributions of the national ecological debt to management.

Finally, the third research question relates to the introduction of accounting. Ecological debt accounting provides some conceptual reframing in relation to existing management tools, while remaining anchored in current practice. In order to be implemented, a management tool must be useful, meet pre-identified needs or, if these needs have not already been formulated, offer new potential. This raises the legitimate question of whether the benefits of recording ecological debt outweigh the investment required. If this is the case, we will have to consider how to institutionalise such accounting.

To answer these questions and provide input for the research, we are attempting to construct an accounting system for ecological debts based on the texts framing water policy and the information systems of the Seine-Normandy Water Agency (SNWA), which operates in one of the six metropolitan river basins. The timeframe for this work is that of the SNWA's 10^e intervention programme, i.e. the period 2013-2018 (Table 33). The main stages of the method are those used to define capital (liabilities) according to the CARE business accounting model business accounting model (Rambaud and Chenet, 2020; Rambaud, 2015). This method has been developed by the Ecological Accounting Chair, but has not been published.

The tables of accounts obtained from the accounting framework were presented to the SNWA, the Ministère de la Transition écologique and experts regularly involved in water management. The purpose of these presentations was to obtain their opinions on the various accounting conventions, the differences compared with current management and the resources required to set up such accounting.

Table 33 Temporalities to which the Water Agencies are subject (in red: years studied for this work)

Year	Monitoring programme	Intervention programme	SDAGE
2010		9 th	1 st WFD cycle
2011			
2012			
2013	MP	10 th	2 nd WFD cycle
2014			
2015			
2016			
2017			
2018			
2019	MP	11 th	3 rd WFD cycle
2020			
2021			
2022			
2023			
2024		12 th	3 rd WFD cycle
2025	MP		
2026			
2027			

The chapter thus begins by presenting the construction of the accounting of the ecological debts associated with the water bodies of the Seine-Normandy catchment area. We first present the work

done on the biophysical database. A method section precedes the tables of results that we were able to construct.

The second part explains how monetary accounting was constructed. The results are then presented.

Finally, the discussion returns to the conventions adopted and compares them with other possibilities that we might have adopted. The limits of the technical work are also explained. We then provide some answers to the other two lines of research: the micro-macro link and the potential uses of accounting.

A brief conclusion summarises the contributions to the thesis.

2. Construction of biophysical accounting

2.1. Method

The data provided by the Seine-Normandy Water Agency (SNWA) gives an overview of the state of the water bodies in the region and of some of the management carried out (through the description of the projects it subsidises). We are going to start by putting the bodies of water into accounts, i.e. by taking their definition and incorporating it into the liabilities in the form of capital. Next, we will reclassify the SNWA subsidies according to their accounting nature. To do this, it is necessary to understand how they have been used by the institutional units (companies, administrations, associations or individuals) that receive them. We will describe the conventions adopted and the methods used to restate the data. The discussion in this chapter will compare the alternatives that were possible and provide a better understanding of the choices made.

2.1.1. Definition of liabilities: ecological entities to be preserved¹⁷¹

Four elements are discussed here to define bodies of water as capital:

- 1) *Defining the entities that are the source of preservation concerns*: this definition should make it possible to use everyday words to identify the natural entities that are likely to be considered as capital.
- 2) *The ontological description of capital*. The difference with the previous point is that translators (or mediators) are mobilised to describe the capitals in detail. A translator is a point of passage in a system of interrelations that makes it possible to understand the ecological state of the entity under consideration and to represent it within the collective. Translators can be indicators, people or other non-human entities¹⁷². While the definition is not likely to evolve, the ontological description may change as a result of developments in scientific knowledge (e.g. a change in measurement protocol, a new dimension that becomes measurable), relations with the economy (new impacts or uses of the entity to be preserved require new measurements: e.g. new pollution that did not exist before), etc. These changes are therefore more likely to occur in the medium term. These changes therefore tend to occur in the medium to long term. For bodies of water, the translators we will use here will be indicators.
- 3) *The preservation thresholds* adopted: for each indicator (or translator), it must be possible to choose a reference level that constitutes the state in which we wish to preserve the capital entity. This could be a maximum pollutant concentration, an animal population size, etc.
- 4) *The existence of preservation processes*: for an entity to be considered as capital, at least one process must exist to prevent impacts (e.g. wastewater treatment plant, *carbon capture and storage* system, bird scaring devices on wind turbines) or to restore it afterwards.

2.1.1.1. Concern for preservation

Collective water management in France is legally organised around a set of texts starting at European level (directive) and working down to national level (law, decrees, etc.), from river basin to local level (decisions by local water commissions, river contracts). The concerns for the preservation of water are successively recalled:

The preamble to the Water Framework Directive (WFD) states that:

¹⁷¹ Corresponds to phase 1 of the CARE model (definition of natural capital).

¹⁷² One example of this is the shrimp populations used as proxies to estimate the state of scallops in the Bay of Saint-Brieuc. The translators of scallops are shrimp (Callon, 1986).

*"Water is not a commodity like any other, but a heritage that must be protected, defended and treated as such."*¹⁷³

Article 1^{er} of the Loi sur l'Eau et les Milieux Aquatiques (LEMA) states that:

*"Water is part of the nation's common heritage. It is in the public interest to protect and enhance it and to develop the resources that can be used, while respecting the natural balance."*¹⁷⁴

The objective stated in the preface to the Schéma Directeur d'Aménagement et de Gestion des Eaux (SDAGE) for the Seine-Normandie basin is to "restore the quality of water and aquatic and wetland environments" (Seine Normandy Basin Committee, 2016, p. 2).

The entities of concern are surface and groundwater bodies, taken independently of each other. These terms are defined in the WFD. In particular, surface water bodies are defined as:

*"A distinct and significant part of surface waters such as a lake, reservoir, river or canal, part of a river or canal, transitional water or part of coastal waters"*¹⁷⁵.

In these texts, water is often presented first and foremost as a resource. On the other hand, the ecosystem approach permeates the body of all these texts. For example, the WFD includes a major section on the ecological quality of environments, with no specific reference to services, but rather to the integrity of the environment itself. In addition, the title of the French law introduces the notion of "aquatic environments". The Seine-Normandie SDAGE also refers to "aquatic and wet" ecosystems in its preface.

We can also see that water is considered to be a unique entity on a French scale ("national heritage"). We will come back to this point below.

2.1.1.2. Definition of capital

The Water Framework Directive (WFD) sets out the definitions and general principles for water bodies. Definitions vary according to the type of water body (groundwater, coastal, transitional, rivers and water bodies). We will restrict our work to rivers. Water bodies are defined by three elements: their geographical extension, the quantity of water, and their chemical and biological characteristics.

The *geographical boundaries* of the surface water bodies are defined in the inventory of the Seine and Normandy coastal watercourses basin (Seine Normandy Basin Committee, 2013).

Quantitative aspects are defined by flows (the quantity of water flowing through a section of watercourse per unit of time in m³ /sec.), measured at the main confluence points in the basin and at certain strategic points (known as "nodal points"). For the purposes of this work, we will leave this dimension aside (the section on the BA). 4.1.1 discusses this choice).

The *qualitative aspects* cover several dimensions articulated according to aggregation rules which make it possible to calculate the overall status of the body of water (Figure 41)¹⁷⁶.

¹⁷³ Directive 2000/60 BA of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, paragraph (1).

¹⁷⁴ Law no. 2006-1772 of 30 December 2006 on water and aquatic environments, article 210-1.

¹⁷⁵ Directive 2000/60 BA, article 2, §10.

¹⁷⁶ It should be noted that qualitative aspects naturally depend on quantitative aspects: biological life requires a reasonable quantity of water, pollutant discharges are more or less diluted depending on the flow, etc.

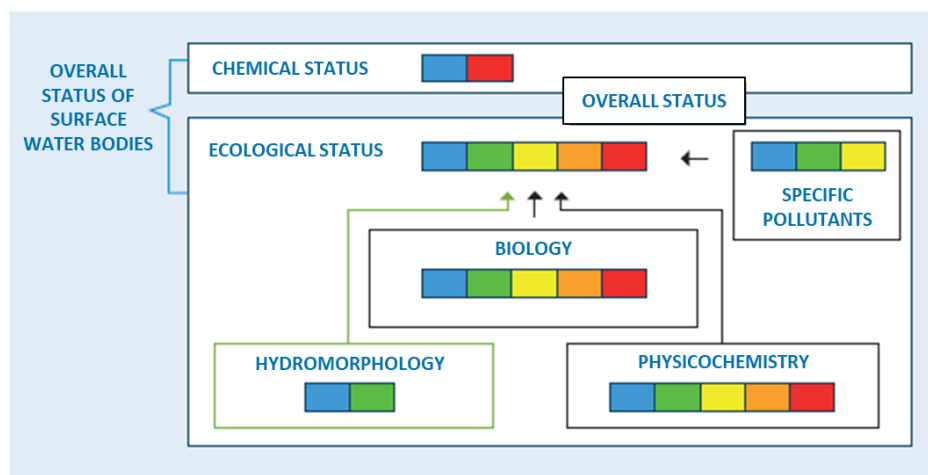


Figure 41 Process for assessing the status of a body of water (Seine Normandy Basin Committee, 2016, p. 44)

Legend: the colours represent the status of the "quality elements": blue = very good, green = good, yellow = average, orange = poor, red = bad. The arrows indicate which quality elements are aggregated to calculate the status of the next level up.

The overall status of surface water bodies is considered to be good when **their** chemical status and ecological status are *at least* good.

For chemical status, the Seine-Normandy SDAGE states that:

"The chemical status of a body of water is determined on the basis of the concentrations of a list of 41 substances in the water (directive 2013/39 BA adds 12). The threshold values delimiting good and bad chemical status are established in relation to the toxic effects of these substances on the environment and health: these are known as environmental quality standards (EQS)". (Seine Normandy Basin Committee, 2016, p. 43)

These standards are defined nationally. The WFD specifies that values must not exceed "standards established to ensure the functioning of the characteristic ecosystem"¹⁷⁷. The standards are defined in terms of the concentration of the targeted substances in the water.

The ecological status of a body of water is defined in the WFD as "the expression of the quality of the structure and functioning of aquatic ecosystems associated with surface waters"¹⁷⁸. Normative definitions of "quality elements" are given in Annex V to characterise ecological status. Four categories of quality elements must be analysed:

- Biological quality elements. These correspond mainly to the taxonomic composition and abundance of certain groups (phytoplankton, macrophytes, etc.). Certain functional traits of phytoplankton must also be analysed (frequency and intensity of blooms) as well as the presence of 'sensitive' plant and fish species such as salmonids.
- Physico-chemical quality elements. These include the quantity of oxygen in the water, its temperature, the concentration of nutrients (phosphate, phosphorus, ammonium, nitrate and nitrite) and acidification.

¹⁷⁷ Directive 2000/60 BA, Annex IV, §1.2.1.

¹⁷⁸ Directive 2000/60 BA, Article 2, §10.

- The concentration of specific pollutants in the water is also a factor. The SNWA database lists four non-synthetic metal pollutants (zinc, arsenic, copper, chromium) and sixteen synthetic pesticides (chlortoluron, metazachlor, aminotriazole, nicosulfuron, oxadiazon, ampa, glyphosate, 24mcpa, diflufenicanil, imidacloprid, 24d, biphenyl, boscalid, metaldehyde, chlorpropham, xylene). With regard to the standards defined by the Member States, the WFD specifies that:

"As far as possible, both acute and chronic data should be obtained for the taxa listed below which are relevant to the type of water body concerned and for any other taxa for which data are available. This 'core set' includes: algae or macrophytes; daphnia¹⁷⁹ or organisms representative of saline waters; fish"¹⁸⁰.

And, further on: "iv) the resulting standard must be subjected to a critical examination by colleagues and to public consultation in order to allow the calculation of a more precise safety factor."¹⁸¹

- Hydromorphological quality elements (or hydromorphological conditions in the SDAGE). The "hydro" dimension is measured by the quantity and dynamics of the flow, the connection to groundwater and continuity, which must allow the migration of organisms and the transport of sediments. The "morphological" dimension includes "channel types, variations in width and depth, flow velocity, substrate conditions and bank structure and condition". Hydromorphological quality can move a body of water from "very good ecological status" to "good ecological status", but cannot be the cause of a classification of "average" or "poor" status.

Based on these general definitions, the Member States choose "indicative parameters" to characterise and quantify the "quality elements". This also makes it possible to define the thresholds for determining whether the state is good, average, mediocre or poor. This process involves experts in biology, hydrology, etc. (Bouleau et al., 2017; Marchal, 2020). Table 34 shows the evolution of indicators for assessing the status of water bodies in France. Many indicators are common to all European countries, as they are classically used in physical chemistry (pH, pollutant concentrations, etc.). (Marchal, 2020). On the other hand, others have been created for the application of the WFD (biological status indices in particular, which are often specific to each member state). Since the WFD only sets the objective of good status, the definition of indicative parameters for hydromorphology began later. National methods now exist (Frédéric et al., 2021) but they do not play as important a role as the other biological and chemical quality indicators.

¹⁷⁹ Crustaceans measuring between 1 and 4 mm that are part of the zooplankton family.

¹⁸⁰ Directive 2000/60 BA, Annex V, §1.2.6.

¹⁸¹ *Ibid.*

Table 34 Changes in methods for assessing surface water status (source: adapted from Seine Normandy Basin Committee, 2016, p. 45)

	État des lieux 2004	SDAGE 2010-2015	État des lieux 2013	SDAGE 2016-2021 Etat initial 2015
Nb ME	413	1 659	1 681	1 650
Nb stations	282	671	1 067	1 704
Réseaux de surveillance	RNB	DCE (RCO+RCS) + RCB	DCE (RCO+RCS) + RCB + réseaux locaux	DCE (RCO+RCS) + RCB + réseaux locaux
Période d'évaluation	2001-2002	2006-2007	2010-2011	2011-2012-2013
Paramètres Indicateurs	Matières organiques et oxydables	État écologique :	État écologique :	État écologique :
	MES	Bilan de l'oxygène Nutriments (matières azotées et matières phosphorées)	Bilan de l'oxygène Nutriments (matières azotées et matières phosphorées)	Bilan de l'oxygène Nutriments (matières azotées et matières phosphorées)
	Turbidité	pH, température	pH, température	pH, température
	Nitrates	IBGN, IBD, IPR	IBGN, IBD, IPR	IBGN, IBD, IPR, (normalisés au format EQR) + IBMR
	Matières phosphorées	Polluants spécifiques (9 substances)	Polluants spécifiques (9 substances)	Polluants spécifiques (9 substances)
	Métaux (sédiments)			
	HAP (sédiments)			
Méthodologie	Pesticides (eau)	État chimique : 41 substances (eau)	État chimique : 41 substances (eau)	État chimique : 41 substances (eau)
	IBGN, IPR			

Legend: orange box: physico-chemical status; green box: biological status; blue box: specific pollutants. RNB: Réseau national de bassin (National River Basin Network); RCO: Réseau de contrôle opérationnel (Operational Control Network); RCS: Réseau de contrôle de surveillance (Surveillance Control Network); MES: matières en suspension (Suspended Solids); PAH: hydrocarbures aromatiques polycycliques (Polycyclic Aromatic Hydrocarbons); pH: potentiel hydrogène (Hydrogen Potential); RCB: réseaux complémentaires de bassin (Complementary River Basin Networks); IBGN: indice biologique global normalisé (Standardised Overall Biological Index); IBD: indice biologique diatomées (Diatom Biological Index); IPR: indice poisson en rivière (River Fish Index); EQR: ecological quality ratio; IBMR: indice macrophytique en rivières (River Macrophytic Index); SEQ: Système d'évaluation de la qualité (Quality Evaluation System).

In most cases, the WFD explicitly states that the reference for achieving very good status corresponds to "undisturbed conditions"¹⁸² by "distortions caused by human activity"¹⁸³. Good status corresponds to "slight modifications"¹⁸⁴ and average status to "moderate" differences or disturbances¹⁸⁵. The

¹⁸² Directive 2000/60 BA, Annex V (terms used several times).

¹⁸³ *Ibid.*

¹⁸⁴ *Ibid.*

¹⁸⁵ *Ibid.*

French version of this is the measurement of the difference between the status of the bodies of water assessed and the reference bodies of water, unmodified by human activity.

As of the 2016 SDAGE, the parameters indicative of biological status have been intercalibrated between European countries so that they can be compared (for a description of this process, see Marchal, 2020). This exercise involved calibrating the biological indices in two phases (2005 then 2012). For this, an ecological quality ratio, which takes values between 0 and 1, is defined as the deviation from the reference value for each parameter indicative of biological status.

Calculating the ecological status of bodies of water involves all dimensions, with biological status taking precedence. The rules are detailed in Figure 42. The choice of indicators involves dimensions that have causal relationships (Marchal, 2020) ES: physico-chemical quality and hydromorphology influence the animal and plant populations that can develop in aquatic environments. It is therefore difficult to predict the effects of a variation in one indicator on the overall score.

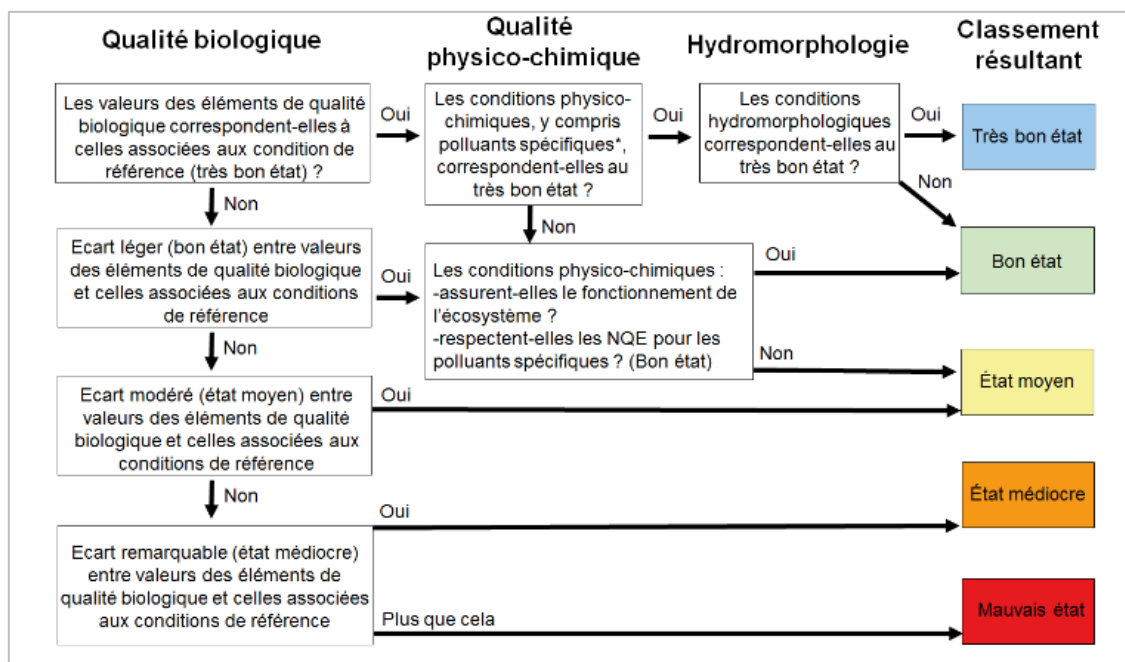


Figure 42: Rules for calculating ecological status (source: Ministère de la Transition écologique et solidaire, 2019)

It should be remembered here that our objective is not to construct an accounting system that takes stock of the state of water bodies, but rather of the indebtedness of institutional units to water bodies. This choice implies taking as the statistical unit the institutional units (companies, administrations, Households, etc.) defined in the System of National Accounts (United Nations et al., 2011) and not the ecosystems themselves (the discussion in this chapter returns to the differences between the two possibilities).

The indicator used to qualify the ecological debt must correspond to a measure of what the company owes to the environment. We will therefore base our analysis on ecological status classes (we exclude chemical status from the analysis, as we were unable to use this data; ideally, we should have defined debts on the basis of the overall status of water bodies). The status classes are therefore converted into numbers (1: very good status, 2: good status, 3: average status, 4: poor status, 5: poor status). The legislation sets good status as the objective. Thus, the biophysical value required by the organisations is the number of classes that need to be improved to achieve good status. It is therefore a whole number between 0 and 3.

Figure 43 summarises the description of the ontology of "water body" capitals that we have just described. It gives an overview of the origin (European and French law) and the articulation of the elements defining water bodies.

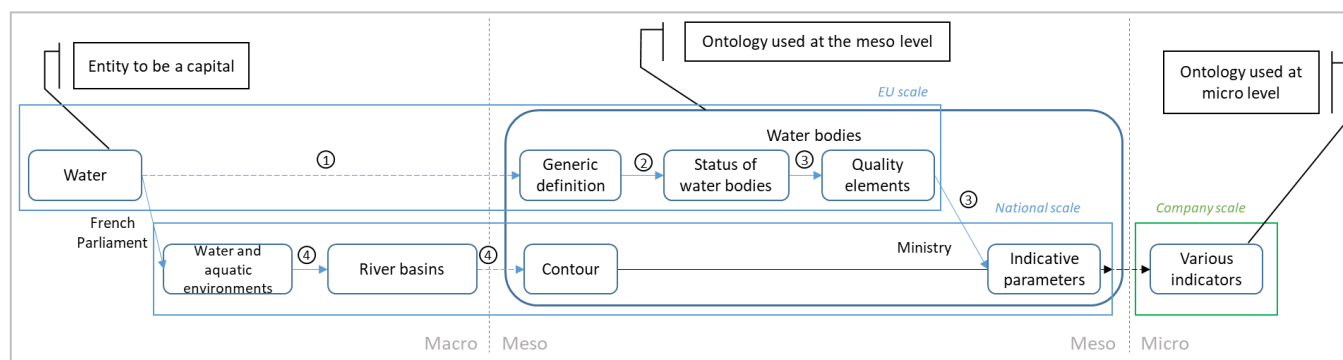


Figure 43 Summary of elements used to define the "water bodies" capital ontology

Legend: 1: verbal definition of the object of conservation concern announced in the preamble to the Water Framework Directive; 2: definition of nature; 3: characterisation; 4: geographical breakdown. The grey dotted lines delimit areas of representation that can be likened to accounting areas. (Feger and Mermet, 2021a).

From the point of view of the Water Agencies, we will use the meso definition of water bodies, which is not necessarily the one used by the organisations. A reading of the impact studies shows that the companies rely on the SNWA's inventory to describe the initial state of the body of water they are impacting. However, the impacts anticipated by the company are described in different terms (strong, medium, weak impact), without reference to the indicative parameters for the status of the bodies of water.

2.1.1.3. Level of capital preservation

Establishing the level of preservation of capital follows a slightly different logic from defining the status of water bodies. Overall, we find the same governance and construction stages described in the previous section, but with a few differences (Figure 44).

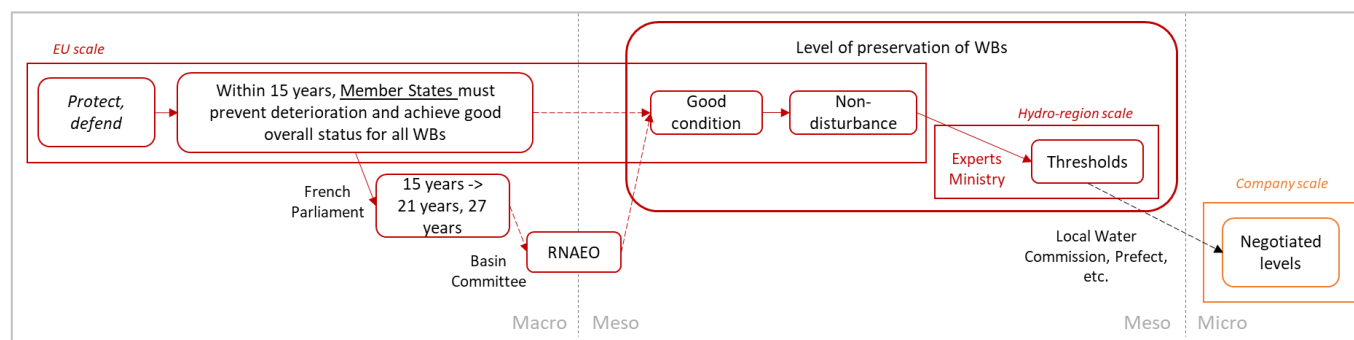


Figure 44 Construction of water body maintenance thresholds

Legend: RNAOE: risk of not achieving ecological objectives. The dotted arrows indicate a break in logic between, at macro level, the definition of public policy objectives aimed at preserving water mass capital, and the translation of preservation thresholds (solid arrows) from everyday language to quantified indicators.

Each level (from the various bodies and General Government departments down to the company) takes the definition of the objectives of the higher level and translates them for the level that follows. However, it should be noted that the EU acts in two ways.

On the one hand, it defines a global framework for action that does not correspond exactly to the definition of thresholds for preserving water body capital. In its preamble, the WFD defines a general intention: "Water is not a commodity like any other, but a heritage that must be protected, defended and treated as such". It translates into legal obligations: "Member States shall protect, enhance and restore all bodies of surface water [...] in order to achieve good surface water status at the latest 15 years after the date of entry into force of this Directive"¹⁸⁶ (similar objectives apply to other bodies of water). A framework for derogations exists. It allows Member States and the EU to negotiate objectives for achieving good status of water bodies and to postpone some of these objectives beyond 2015, to 2022 or 2027¹⁸⁷. In particular, at river basin level, the assessment of the risk of failure to achieve ecological objectives (RNAOE) makes it possible to exclude certain bodies of water under certain conditions. This must be "justified" by technological criteria (if the work requires more time), if natural conditions do not allow it or if the costs of achieving it are unreasonably high (on this last point, see in particular Feuillette et al., 2016, 2015).

On the other hand, the WFD provides the framework for defining the capital preservation thresholds themselves (but not their level):

- Quantitative thresholds for surface water are defined by two flows corresponding to objectives for achieving good status of water bodies: low-water flow and emergency flow. As this dimension is not used in this study, we will not go into detail here.
- The status of water bodies is defined as "the expression of the quality of the structure and functioning of aquatic ecosystems associated with surface waters"¹⁸⁸. In Annex V of the directive (where the quality elements are also described), the way in which their status is to *be understood* is specified: each body of water must be in a state showing "no or very little anthropogenic alteration"¹⁸⁹, or be "undisturbed"¹⁹⁰. This is an important first translation, since it explicitly refers to two aspects: human impact and a reference state.

To define the threshold values for the indicator parameters, bodies of water considered to be "undisturbed" are chosen within the river basin. Indicator thresholds are chosen by hydro-region (a smaller scale than the river basin) and by river size. A decree summarises all these national choices¹⁹¹.

In the time available for our study, it was not possible to study in detail the monitoring of the entire chain of translation of objectives. In particular, the finest level, i.e. the company level, is not accessible. We will therefore consider here that a biophysical debt is incurred when the overall status of a body of water in very good or good condition deteriorates to a lower level: average, poor or bad. Given the

¹⁸⁶ Directive 2000/60 BA, Article 4, §1

¹⁸⁷ Directive 2000/60 BA, Article 4, §4

¹⁸⁸ Directive 2000/60 BA, Article 2, §10

¹⁸⁹ Directive 2000/60 BA, Annex V, §1.2

¹⁹⁰ *Ibid.*

¹⁹¹ [Arrêté du 25 janvier 2010 relatif aux méthodes et critères d'évaluation de l'état écologique, de l'état chimique et du potentiel écologique des eaux de surface pris en application des articles R. 212-10, R. 212-11 et R. 212-18 du code de l'environnement.](#)

way in which good overall status is calculated, a debt is therefore incurred as soon as one of the sub-categories is affected by the action of an organisation¹⁹².

The finest level of allocation of ecological budgets is therefore left out. Different activities may have a greater or lesser impact on a body of water, without all having to comply with the threshold defined for the entire body of water. Systems of distribution or compensation between players can therefore be put in place for each of them (for example, farmers pollute bodies of water without being held responsible, the costs associated with treatment by a wastewater treatment plant being socialised by the authorities). Thus, individual thresholds are linked to a number of parameters, including their inclusion in the game of players managing or having an influence on the state of the body of water and their negotiating capacity.

2.1.1.4. Existence of means of preserving this capital

For an item to be considered as capital, at least one means of preservation must exist. There are many such means, and they will be described in the following sections.

It should be noted, however, that the lists of pollutants used to define good status include pollutants for which there is no means of ex-post preservation (restoration) and for which prevention (ex-ante) is very difficult, as these are pollutants that are ubiquitous in everyday life. This is the case for so-called ubiquitous pollutants (PAHs¹⁹³ and PCBs¹⁹⁴ for example), which are present in water, in the air, but also in sediments and other terrestrial environments. (Seine Normandy Basin Committee, 2013). With current resources (technological, human and financial), it is not feasible to treat this pollution once it has reached the natural environment (Feuillette and Clerc, 2022).

We will therefore consider that there is no way of preserving bodies of water from these pollutants (there are avoidance actions, which aim to stop the production of these elements entirely, but no real prevention or restoration). This means that we will not be taking their volume or concentration into account when measuring the status of water bodies. With regard to biophysical aspects, it should also be noted that management measures for these pollutants are not solely a matter for water policies, despite the fact that their concentrations most often downgrade the status of water bodies. On several occasions, the SDAGE presents assessments with and without these substances, in order to demonstrate the progress made as a result of the actions within its remit.

In this exercise, we therefore consider that these substances are outside the scope of the strict policy of the Water Agencies and that no debt is incurred as a result of the storage of these compounds in water bodies.

2.1.2. Definition of assets: uses that degrade bodies of water¹⁹⁵

In the accounting model we are developing, assets are conceived as degrading uses of capital. The use of bodies of water must therefore reflect both the impact on natural capital and the benefit to the

¹⁹² It is not necessary to identify precisely which organisation is involved, but this makes it possible to exclude what are intrinsic variations in capital, to use CARE's vocabulary, or in terms of NA, other changes in volumes.

¹⁹³ Polycyclic aromatic hydrocarbons.

¹⁹⁴ Polychlorinated biphenyls.

¹⁹⁵ Corresponds to phase 2 of the CARE model (description of the insertion of capital into the business model).

stakeholder. To do this, we first need to identify the sources of degradation that impact the indicative parameters¹⁹⁶.

The main users of water bodies can be grouped into the following categories:

- Households producing wastewater. Households are initially responsible for their discharges. There is an obligation to install a non-collective sanitation system outside built-up areas, or an obligation to connect to the "mains sewer" if this is not the case (note that this obligation is linked to the building, and therefore to the current owner). Local authorities are responsible for monitoring these systems.
If there is a public sewerage system, then the Households are responsible for cleaning up the wastewater. We therefore consider that the ecological debt is generated by Households in all cases, but that it is transferred to the community when the wastewater enters the public sewer system.
- Industry: water withdrawal and discharge of heated water, with modified pH, chemical pollutants or macropollutants.
- Farmers: abstraction for irrigation, wastewater discharges and diffuse pollution (pesticides, fertilisers).

The pressure data available for each body of water allows us to draw up a partial table of uses (Table 35).

¹⁹⁶ Other sources of non-anthropogenic variation (natural disasters, immigration of species, dynamics of erratic species, etc.) or accidental variations may cause the indicative parameters to vary. These special cases are dealt with in the "Other changes in volumes and adjustments" account.

Table 35 Indicative parameters for water body status and pressure

<u>Status</u>	<u>Quality element</u>	<u>Indicator parameter name</u>	<u>Connection to pressure variables</u>
Biological condition	Diatoms	Diatom Biological Index (IBD)	
	Global	Global Biological Index (GBI)	
	Invertebrates	Multimetric invertebrate index (I2M2)	
	Global	Adapted Biological Global Index (IBGA)	
	Fish	Indice Poisson en Rivière (IPR) (River Fish Index)	
	Macrophytes	River Macrophytic Biological Index (IBMR)	
Physico-chemical state	Oxygen balance (BILANO2)	Dissolved oxygen (O2) O ₂ saturation rate (SATO2) Biological O ₂ demand (BOD5) Dissolved organic carbon (DOC)	
	Nutrients (NUT)	Phosphate (PO43)	Point-source macro-pollutant
		Phosphorus (PHOS)	Point source macropollutant; diffuse phosphorus
		Ammonium (NH4)	Point-source macro-pollutant
		Nitrite (NO2)	Point-source macro-pollutant
		Nitrate (NO3)	Point-source macro-pollutant; diffuse nitrates
	Temperature (TEMP)	Water temperature (TEMPE)	
	Acidification (ACID)	pH min (PHMIN) pH max (PHMAX)	
Specific pollutants	Non-synthetic (NONSYNTH)	List of 4 pollutants	Point-source micropollutant; plant protection products
	Synthetics (SYNTH)	List of 16 pollutants	Point-source micropollutant; plant protection products

Legend: in bold: the data actually used for our work. The names of the variables in the SNWA database are given in brackets. The last column indicates the name of the pressure we use to associate pressures with institutional sectors.

The data available on pollution (nutrients, temperatures, acidification, synthetic and non-synthetic pollutants) means that it can be attributed in part to the various institutional sectors. Following the example of CO₂ (Rambaud and Chenet, 2020) the corresponding use is "**Pollutant storage**", which can be broken down according to the name of the pollutant in question. The biophysical unit used was defined above as "**number of condition classes to be improved**". This unit leads to all types of jobs being measured in the same way. It therefore does not explicitly reflect the ecological characteristics of the water bodies (tonne of pollutants present in the environment, drop in IBD, etc.).

For each body of water, the starting point is the *presence* (and not the intensity) of one or more of the pressures listed in Table 35 as well as their origin(s). These origins had to be reclassified to coincide with the institutional sectors (Table 36).

Table 36 Attribution of pollution sources to institutional sectors

Macropollutant origins	Responsible institutional sector
Network connections	GG
Urban rainfall discharges	GG
Networks	GG
Waste water treatment plant (WWTP)	GG
Non-collective sanitation (ANC)	Households
ANC or lack of sanitation	Households
Industry	NFC
Upstream	Undetermined
Origin of micropollutants	Responsible institutional sector
Discharge from municipal wastewater treatment plant	GG
Urban rainfall discharges	GG
Industrial waste	NFC
Upstream (diffuse)	Undetermined
Upstream	Undetermined
Historical industrial pollution	Undetermined
Historical sedimentary stock	Undetermined
Point sources	Undetermined
Diffuse	Undetermined
Nitrate origins	Responsible institutional sector
Agriculture, agricultural land, turning over of grassland and disappearance of livestock farming, arable land	NFC
Sources of phosphorus	Responsible institutional sector
Agricultural soil leaching	NFC
Sources of diffuse plant protection products	Responsible institutional sector
Yes	NFC
Indet	Undetermined

Legend: GG: General Government, NFC: Non-Financial Corporations

We have simply divided the ecological debts of each body of water between the pressures and the institutional sectors. Only the presence/absence of pressure from a sector allows us to make this breakdown; we do not have access to the relative intensity of pressure by type of player (who emits how many tonnes of pollutants into the body of water). Thus, if a body of water with an ecological debt of 1 (average state) is subject to macropollutant discharges from two institutional sectors (Households and Non-Financial Corporations), each sector is assigned a responsibility of 0.5 (see Table 37ME1). Similarly, if a body of water with a debt of 1 also suffers nitrate pollution, this will have a contribution of 0.3, as will the other two pressures (Table 37ME2).

Table 37 Examples of the distribution of ecological debt by sector and pressure

WB1	NFC	GG	HH	Total
Natural assets - uses				1
Macropollutant warehousing	0,5		0,5	
Micropollutant warehousing				
Nitrogen (diffuse) warehousing				
Phosphorus (diffuse) warehousing				
Phytosanitary warehousing				

WB2	NFC	GG	HH	Total
Natural assets - uses				1
Macropollutant warehousing	0,3		0,3	
Micropollutant warehousing				
Nitrogen (diffuse) warehousing	0,3			
Phosphorus (diffuse) warehousing				
Phytosanitary warehousing				

Mathematically, the distribution of impacts on bodies of water can be formalised as follows:

$$d = \sum_{j=1}^m \sum_{i=1}^n c_{i,j}$$

With d the total ecological debt on the body of water, n the number of institutional units impacting the body of water, $i \in \llbracket 1; n \rrbracket$ m the number of different types of impact on the body of water (giving rise to the recording of separate assets), $j \in \llbracket 1; m \rrbracket$ and $c_{i,j}$ the contribution to the ecological debt (which is therefore expressed in the same unit as the ecological debt).

The breakdown is based on the following calculation:

$$c_{i,j} = \frac{d}{n + m}$$

This means that we have had to make three strong assumptions in order to estimate the $c_{i,j}$ values. Firstly, each sector contributes at the same level to the degradation of the water body score. Secondly, each pressure contributes in the same way to the degradation of the water body. Finally, adding an institutional sector or an additional pressure has the same effect of diluting the ecological debt of the other pressures and institutional sectors.

2.2. Results - Biophysical asset accounts

On the liabilities side, the ecological debt in 2013 was 1306 state classes to be improved, while in 2019 it will be 1218, representing a net improvement of 88 state classes.

Table 38 shows the debts in 2013 and 2019 and provides a better understanding of their evolution. It should be noted that the vast majority of water bodies in the catchment area (1,223) are in average, good or very good condition and that about a third fluctuate between these states. The number of bodies of water in poor or mediocre condition is therefore fairly limited, as are the very significant variations in condition. The latter is probably due to a threshold effect between the status classes of the indicative parameters most often affected. Furthermore, the 4% increase in the number of bodies of water with good or very good status, i.e. 70 bodies of water, is in fact divided into 42 net improvements and 28 bodies of water that were not previously assessed, but will be in good status in

2019. In addition, across all the bodies of water, there has been a fairly high rate of renewal, but the balance is positive: 44% of the bodies of water have changed status (400 improvements and 330 deteriorations, excluding those not assessed in 2013).

The number of bodies of water consistently impacted since before 2013 is 470 (389+65+16).

It should be noted that there may have been changes in status during the period without this being reflected in the 2019 assessment. Reduction or restoration actions may have been undertaken to combat impacts, thereby offsetting pressures on water bodies during the period. As the biophysical impact of the conservation actions subsidised by the SNWA has not been quantified, we cannot say more on this point. This will have to be taken into account when analysing preservation expenditure.

The Water Agency's action is therefore rather difficult to disentangle from this analysis alone. A similar result can be found by comparing the amounts spent per body of water and the change in the biophysical debt, which does not allow us to conclude on the effect of spending. To get an idea of the SNWA's action, this would have to be compared with a counterfactual, a scenario without their action.

Table 38 Change in debt related to water bodies

		Debt 2019				Total
		0	1	2	3	
Debt 2013	0	408	200	11	4	623
	1	226	389	82	20	717
	2	25	112	65	13	215
	3	6	20	11	16	53
	NA	28	12	2	1	43
Total		693	733	171	54	1651

Key for interpretation: 408 bodies of water remained in good or very good status (debt = 0) between 2013 and 2019, 226 bodies of water went from average status to good or very good status and 200 went from good or very good status to average status.

The biophysical stock accounts themselves are presented in Table 39. As asset accounts mirror liability accounts by construction,¹⁹⁷ does not include the latter in the illustration. To find the debts for each sector, simply add up the values for each column.

It should be noted that the figures in Table 39 do not correspond to the state of the bodies of water, but to the quantity of impacts linked to individual uses.

¹⁹⁷ Remember that nature's natural credit account is equal to the sum of the ecological debts of economic players.

Table 39 Biophysical wealth accounts - assets

Assets	Asset (2019)							Total
	NFC	GG	SNWA	HH	NPI	Unknown	Nature	
Non financial assets								
Natural assets - uses	652,2	267,8		2,4		314,7		1237,0
Macropollutant warehousing	27,1	243,7		2,4		1,5		274,7
Micropollutant warehousing	36,5	24,1		0,0		16,9		77,4
Nitrate warehousing (diffuse)	89,4	0,0		0,0		0,0		89,4
Phosphorus warehousing (diffuse)	135,0	0,0		0,0		0,6		135,6
Phytosanitary warehousing	364,2	0,0		0,0		15,7		379,9
Unknown	0,0	0,0		0,0		280,0		280,0
Natural assets - commitments							1218	
Natural loans - Water bodies							1218	
Financial assets								

Legend: NFC: Non-Financial Corporations, GG: General Government, NPI: Non-profit institutions, NA: not applicable.

The discrepancy between the total sum of uses created by the economic sectors (1237) and the claims of the Nature institutional sector (1218) is an artefact due to data processing.

Most of the impacts are linked to agricultural pollution (phosphorus, nitrates and plant protection products) and Households discharges of pollutants. This is consistent with the analyses in the status report, which notes that the risks identified between now and 2027 are prioritised as follows (Seine Normandy Basin Committee, 2013):

- Hydromorphology: 61% of water bodies
- Pesticides: 41% of water bodies
- Macropollutants (mainly linked to wastewater and stormwater management systems): 27% of water bodies

It should be noted, however, that the presentation of the data using this new unit highlights the role of agricultural activity in the impacts: 48% of the status classes lost are due to agricultural pollution, while 20% are due to macropollutants.

3. Construction of monetary accounting

3.1.Method

3.1.1.Definition of preservation activities¹⁹⁸

In setting up ecological debt accounting, the aim of this stage is to identify the actions that need to be taken to preserve the natural capitals that have been previously defined in terms of their degrading uses.

Two separate sources are used here to discuss preservation actions. The first relates to the SNWA's estimate of the costs of achieving good ecological status. This exercise was carried out for the first time during the Agency's 10^e programme and repeated for the 11^e programme. Based on knowledge of the costs of the previous programme, it was possible to estimate the actions that would need to be undertaken (and the corresponding costs) to achieve good status for all water bodies. This provides input for the SNWA's budget requests and provides a basis for discussions within the framework of the SDAGEs and the adoption of the Measure program. This work is very similar to putting a figure on the ecological debt by adopting a meso point of view (that of the sub-catchment).

The second source is the 10^e subsidy programme itself. An analysis has made it possible to create a typology of subsidised projects (which are reclassified as "actions"). The SNWA is a General Government body with two main activities:

- The **production of environmental goods and services**. This includes, in particular, operating expenditure and the development of the climate change adaptation plan. Restating this expenditure is not particularly complicated, even if the exact scope of the expenditure covered requires some thought.
- The **redistribution of fees** collected for the use of water and aquatic environments. The SNWA co-finances the projects of local players whose main objective is to contribute to achieving good status for water bodies (during the agency's 10^e programme, which corresponds to the 2^e WFD cycle, this was the SNWA's main objective, which therefore strongly influenced the use of the levy).

This second activity is of particular interest to us. It requires us to look more closely at each project to understand how it fits in with the main activity of the player behind it, and how the subsidies play a part in all this. SNWA subsidies are in fact used to fund one or other of the activities of the organisation that receives them; in principle they are used to benefit water bodies, as the SNWA directs its subsidies in this way. The subsidies cover all or part of the expenditure for the bodies of water at a variable rate. The reclassification of these expenses is therefore identical to that of the subsidies that cover them.

We define four types of activity that have a positive impact on water bodies:

- **Production of an environmental good or service**. As we shall see, this mainly concerns the restoration or creation (fixed assets) or maintenance (operating costs) of wetlands or river banks. Formally, this type of activity is most often undertaken by local authorities (management of sensitive natural areas by the département, for example) and by ecological engineering companies. However, the attribution of this type of activity is simplified and only the final output is considered. So, whether the activity is carried out using internal resources or by subcontracting,

¹⁹⁸ Corresponds to phases 3 (identification of preservation actions) and 5 (structuring of preservation costs) of the CARE model.

it is attributed to the local authority that chooses to produce the good or service (this is the only type of player that actually produces the final good).

If the "creation" turns out to be the restoration of a wetland that has been destroyed or degraded in the distant past without it being possible to identify the party responsible, it will be considered as the production of a new wetland. In order to be recorded in the accounts, it must be possible to attribute a debt to the party that has had an impact on the environment¹⁹⁹. Otherwise, the debt is considered to have been extinguished.

- **Avoidance activity (known as "debt reduction" in CARE):** SNWA sometimes subsidises companies or public authorities to (help to) change a business model, in other words to avoid impacts. This may involve subsidies for conversion to a more virtuous production model (organic farming or a change in industrial technology that emits fewer pollutants, for example).
- **Preservation activities linked to ecological capital:** these are activities aimed at settling a debt. For an identical business model, they must therefore prevent impacts (ex ante) or restore (ex post) the body of water used by the activity of a company or Households. It should be noted that the debt is most often assigned according to a principle of responsibility. So are preservation activities.
- **Access to capital" activity:** this covers expenditure on describing and monitoring the state of bodies of water. Again, this may involve individual or pooled expenditure.

3.1.2. Reclassification of Water Agency subsidies²⁰⁰

3.1.2.1. *Definition of an accounting typology for subsidies*

This stage consists of classifying the subsidies granted by the SNWA according to the item concerned in the general accounts of the players receiving them. Here we create a typology based largely on the CARE model (Rambaud, 2019; Rambaud and Chenet, 2020; Rambaud and Feger, 2019; Rambaud and Richard, 2015). This model distinguishes between the operating cycle (which aims to produce a good or service intended for sale), and the preservation cycle (which brings together activities related to the preservation of financial or non-financial capital).

There are five types of subsidy:

- **Operating subsidy²⁰¹.** There are two possible cases:
 - Operating subsidy (Support for environmental activity): the beneficiary is a company or local authority that produces environmental goods or services, i.e. that contributes to the quality of the environment, from an ecological point of view. In this case, the subsidy is used to support this activity. Examples include the management of a protected area by a local authority, or activities that are not directly linked to a debt owed to a body of water. This category essentially covers activities to raise public awareness and promote water management.

¹⁹⁹ An alternative treatment, which we will not be able to follow here for lack of sufficient data (we would need to be able to distinguish genuine creations from restorations), would be to consider that the debt linked to the impact on the wetland has fallen into the public domain and that it is the responsibility of a public player.

²⁰⁰ Corresponds more or less to phase 4 (value chain and financial investments) of the CARE model.

²⁰¹ The accounting terminology (according to the CARE model) introduces the notion of "top balance sheet subsidy" to mean that the subsidy aims to transform the business model and the notion of "bottom balance sheet subsidy" to refer to those that aim to help the company preserve capital without changing the business model. In principle, balance sheet subsidies (aimed at investments) or income statement subsidies (aimed at current expenses) can also be distinguished. We were unable to do this because we do not know the proportion of investment and operating expenses in projects subsidised by the SNWA.

- Operating subsidy (Avoidance): the beneficiary is a company or local authority whose activity does not contribute to the good quality of the environment from an ecological point of view (or at least, the subsidy relates to a part of the activity that does not aim to produce such a good or service). The subsidy contributes to the transition by directing the investment towards avoidance assets (e.g. a subsidy for an investment in agricultural equipment for mechanical rather than chemical weeding).
- **Preservation subsidy:** this may be aid that encourages investment in environmental preservation assets (e.g. investment or management costs for a wastewater treatment plant), or that enables debt to be paid off directly by funding an ecological restoration project. In the latter case, the new resources are directly usable.
- **Access to capital subsidy:** assistance with access costs (e.g. subsidy for a campaign to measure the state of a watercourse).
- **Traditional subsidies:** some subsidies granted by the SNWA are aimed at objectives other than the preservation of water bodies (e.g. drinking water treatment).

It should be noted that with this typology, a subsidy for an ecological engineering work activity can be either an operating subsidy for environmental support or a preservation subsidy. The first case involves work to create a wetland on land where it is not known whether it was a former wetland or not. The second case corresponds to situations where it is possible to identify the actor impacting the body of water. In this case, work aimed at restoring the environment will be attached to preservation subsidies. Classifying water bodies in this way is eminently conventional (see Appendix K for additional, albeit as yet unfinished, elements).

3.1.2.2. *Application to subsidies paid to a department*

Table 40 illustrates this typology by reclassifying the subsidies granted by the SNWA to a department. This example was used to test and refine the proposed typology. The justifications for the classification of subsidies are given below.

Account 1110 (Local authority wastewater treatment): this is a subsidy which contributes to a water analysis campaign as part of the technical assistance service in the field of water (SATESE), carried out by the department. This is a departmental assistance service that can be requested by local authorities. This expenditure helps to ensure that the sanitation is properly carried out, and is therefore a **subsidy for preservation**²⁰².

Account 1510 (Sanitation technical coordination): idem.

Account 2313 (protection of resources in non-agricultural areas: studies and actions): this involves creating a demonstration area for alternative methods to plant protection products for local authorities and private individuals. Raising awareness is one of the department's public service objectives in favour of the environment. The subsidy will therefore help it to invest in an asset that contributes to this. It is therefore a **subsidy for operating investment (support for an environmental activity)**.

²⁰² In view of the summary description of the source data, it could in fact be a question of controls carried out by the department (measure falling within the scope of its regulatory activity), simple monitoring of the effectiveness of sanitation (effectiveness of the preservation measure, therefore preservation measure) or even a measure as a proxy for the state of the water body (cost of access to capital).

Table 40 Subsidies granted to a département in 2018

SNWA data		Author's classification	
SNWA account	Short title of the project	CARE account of the beneficiary	Subvention type
1110-Local authority purification	SATESE monitoring campaign	Preservation costs	Preservation
1510-Sanitation technical animation	Ass tech and departmental animation	Preservation expenses	Preservation
2313-Protection of resources in non-agricultural areas: studies and actions	Demo area for the development of alternative methods for ZNA	Investment (financial issues)	Environmental activity support
2314-Protection of resources in non-agricultural areas: equipment	Acquisition of alternative weeding equipment	Investment (financial issues)	Avoidance
2410-River development and preservation of aquatic and wetland environments	Studies and monitoring of SNA wetland sites	Operating expense	Environmental activity support
2411-Environmental restoration work	Restoration work on wetlands SNA	Investment (financial issues)	Environmental activity support
2412-Works for ecological continuity	Removal of micro power station - resumption of tow bridge	New resources to pay off debt	Preservation
2413-Land acquisition of aquatic environments	Land acquisition Peat bog	Investment (financial issues)	Environmental activity support
2421-Maintenance work on aquatic environments	Maintenance work on SNA wetlands	Operating Expense	Environmental activity support
3211-Environmental measurement network	Coastal network Department	Access to natural capital (socialized cost)	Access to capital (monitoring)
3404-Events and communication partnerships	Production of communication tools	Operating expense	Environmental activity support

Account 2314 (protection of resources in non-agricultural areas: equipment): this relates to the purchase of mechanical weeding equipment by the departmental service. Weed control is a public service that is generally described as "environmental" (maintenance of municipal areas to keep them "clean" and attractive). Presumably, this does not contribute to the ecological quality of the environment. On the contrary, it can pollute water bodies, particularly when chemical weedkillers are used. In this case, the acquisition of this equipment is aimed at *avoiding* this impact. This expenditure is therefore linked to the department's operating cycle. It is therefore a **subsidy for operating investment (avoidance)**.

Account 2410 (river development and preservation of aquatic and wetland environments): here the expenditure is aimed at gaining a better understanding of the Sensitive Natural Area with a view to its maintenance and enhancement (possibly scientific). This activity is part of the department's operating cycle (managing this area is one of its objectives). It appears to be an expense rather than an investment. This expenditure therefore contributes to the department's environmental goods production activity. The subsidy is therefore an **operating subsidy (to support an environmental activity)**.

Account 2411 (environmental restoration work): this is similar to the previous expense (production of environmental goods) except that it is to improve a fixed asset. This expenditure is therefore not treated as an expense, but it increases the value of the "wetland" asset made available to the public. The SNWA subsidy is an **operating subsidy (to support an environmental activity)**.

Account 2412 (work on ecological continuity): work contributing to the removal of a hydroelectric micro-power station disrupting ecological continuity. This is a subsidy paid 100% by the SNWA for the département to carry out this work. It is therefore a **preservation subsidy**, used as a new resource directly consumed for the work.

Account 2413 (land acquisition of aquatic environments): the expenditure incurred by the département is part of its environmental asset production activity, which consists of creating, acquiring and managing wetlands for the company. The wetland is a fixed asset. The SNWA therefore **grants an operating subsidy (support for an environmental activity)**.

Account 2421 (maintenance work on aquatic environments): the purpose of this expenditure is to maintain the Espace Naturel Sensible for which the département is responsible. Here again, it is a question of its activity of producing environmental goods (a protected area). We are making the simplifying assumption that the work is carried out by an external company. The expenditure is therefore an operating expense. The SNWA subsidy is therefore a **subsidy for an operating expense (support for an environmental activity)** which appears in the income statement.

Account 3211 (Environmental measurement network): this is a subsidy to contribute to the observation network for the microbiological, chemical, radiological, etc. quality of coastal sites and certain taxa. This observation network was set up primarily because of the impact it has on these environments. This means that it cannot be considered as a public service. It can therefore be considered as an expense of access to capital, but one that has been pooled at the level of the Manche département. It seems to be accepted that the department is responsible for running this network and that this responsibility has been officially transferred to it, on behalf (implicitly) of the water users. It is therefore a **subsidy for access to capital**.

Account 3404 (Communication events and partnerships): this involves producing communication tools on the theme of zero phyto. This expenditure can be considered to be part of the department's awareness-raising activity, and therefore a public service, in the same way as its regulatory activity. It is therefore an **operating subsidy (support for an environmental activity)**.

3.1.2.3. Systematic processing of the subsidy programme

The systematic processing of SNWA data is based on these principles, but has been simplified for reasons of time: as SNWA paid out 31,000 subsidies between 2013 and 2018, it was not feasible to classify them individually. In addition, investments and expenses are not differentiated either, as this would have required a much more detailed analysis of the projects.

Subsidies have been processed in two complementary ways: they have been allocated to the institutional sectors in the Sequence of accounts and reclassified according to the typology defined above.

The SNWA data already contained the NAF codes of the beneficiaries. We used the INSEE SIRENE register to add the legal categories of each organisation. The National Accounts Department provided us with the conversion table enabling us to classify the organisations in the correct institutional sectors on the basis of these two categories. A correction has been made: subsidies linked to the Agro-Environmental Measures and the Ecophyto plan pass through the Service and Payment Agency before

being paid back to the agricultural sector. For all these subsidies, we have therefore corrected the GG institutional sector by NFC.

There have been several stages in the reclassification of subsidies.

The first was to classify the ninety level 4 accounts of the SNWA according to the type of subsidy defined above. To illustrate the typology of the SNWA's accounts, see Table 41 shows the names of the level 2 accounts (which are more aggregated than level 4).

Table 41 Aggregated typology at level 2 of the SNWA accounts

I.	Combating pollution
11.	Domestic and similar wastewater treatment plant
12.	Sewerage systems for domestic and similar waste water and rainwater
13.	Combating pollution from non-agricultural economic activities
14.	Waste disposal
15.	Technical assistance in the water sector
17.	Wastewater treatment performance bonuses
18.	Combating agricultural pollution
19.	Miscellaneous pollution
II.	Environmental management
21.	Quantitative resource management
22.	Protecting the resource
23.	Restoration and management of aquatic environments
25.	Drinking water
29.	Basin-wide planning and management
III.	Policy management and development
IV.	Current and other expenditure

We estimated the homogeneity of the subsidies present in these accounts on the basis of a complete reading of five to ten randomly selected projects, and then on the basis of all the short wordings of the works in the account in question. When the accounts included subsidies of the same type (when the account was considered homogeneous), we indicated whether or not the project was linked to an ecological debt as defined above. We then indicated the connection of the subsidised project to the business cycle (exploitation or preservation) and the precise type of action associated (if preservation: reduction or restoration; if exploitation: production or avoidance). Based on this information, we were able to classify the account according to the type of subsidy defined above.

The disconnection of certain subsidies from ecological debts excluded two types of subsidy: for bringing industrial safety standards up to standard (this comes under regulations other than those on water) and for training and raising public awareness (the latter category is too uncertain as to its impact on bodies of water).

Note that work to save water has a special status: it is not possible for us to know whether these water savings are beneficial to water bodies or whether a rebound effect in water consumption occurs. We have nevertheless retained them in our analysis, assuming that ecosystems do indeed have more water available.

Subsidies linked to the exploitation of water resources are classified as "classic" subsidies, meaning that they contribute to an economic activity, but not to avoiding or settling an ecological debt. In fact,

some of these subsidies are intended to help with the potabilisation of water, which is an economic activity that degrades aquatic environments. Potabilisation requires water to be extracted from a body of water, which is detrimental to living organisms ("ecological" low-water thresholds are defined to leave them with a minimum amount of water). Even if some of this water is returned to the natural environment, it will be downstream, often in another body of water. Other subsidies are linked to the protection of water catchment points²⁰³. In any case, as groundwater bodies are not included in our work, these subsidies are outside our scope.

It became apparent that, with regard to our subsidy typology, some accounts included subsidies of several types. Two approaches were therefore adopted. For three accounts, we classified the subsidies from a random sample (Table 42). This enabled us to infer the proportion of each type of subsidy in these accounts as a whole. For another account (1313-Industrial pollution: support measures), it was possible to classify the subsidies more exhaustively on the basis of key words in the work descriptions. 448 subsidies (i.e. 72% of the account) were classified in this way, with the remainder marked NA (not applicable).

Table 42 Information on the sampling of subsidy accounts

Account name	Total number of subsidies	Sample size	Proportion sampled
2410-River development and preservation of aquatic and wetland environments	285	40	14%
2410-Studies on aquatic and wetland environments	539	50	9%
2411-Environment restoration work	1228	60	5%

The "Out of scope" values correspond to expenditure on international cooperation projects. They are excluded from the analysis.

In total, around €82 million of the €2.9 billion subsidies in the programme are classified as "NA" (not applicable), for want of a better term.

These different cases are summarised in Table 43. See Appendix J the classification of the ninety SNWA accounts.

²⁰³ In this case, it is debatable whether the primary objective is to reduce the cost of treatment (in which case the subsidy is simply helping an economic activity, as in the previous case) or to improve the quality of the groundwater body. This is probably rather debatable. In fact, only the perimeter of the catchment point is protected, which should generally have a marginal impact on the entire body of water.

Table 43 Classification of projects encountered according to the type of subsidy defined

Link to a debt owed to an ME	Issues	Type of activity	Type of subsidy
YES	Access	NA	Access to capital
YES	Operating	Avoidance	Avoidance
YES	Preservation	Miscellaneous	Preservation
YES	Preservation	Discount	Preservation
YES	Preservation	Catering	Preservation
YES/NO	Miscellaneous	Miscellaneous	See sampling or manual entry
NO	Operating	Production (approx.)	Activity support approx.
NO	Operating	Production (other)	Classic
YES (Quantitative)	Operating	Avoidance (water savings)	Avoidance
NO (Quantitative)	Operating	Production (water resources)	Classic
Out of scope	Out of scope	Out of scope	Out of scope
NA	NA	NA	NA

The amount of water charges has been added to the table. They come from an analysis of a graph published by the SNWA (Seine-Normandy Water Agency, 2019). The amounts are estimated using a cross product based on the width of each group in the graph (in pixels), and the values shown on the x-axis. Allocation by institutional sector is based on the titles of the categories in the graph. We only have information on total royalties. As a result, we were unable to exclude the large proportion relating to water consumption (for sanitation in particular).

3.1.3. Estimation of monetary values²⁰⁴

3.1.3.1. Estimating the ecological debt

To quantify the ecological debt, we use the amount estimated by the SNWA to achieve 100% good ecological status (Table 44). This calculation was made for the period 2016-2021. In the absence of information for our period, we repeat these results on the assumption that the costs were the same for the period 2013-2018. To give an idea of the variability of these estimates from one cycle to another, we also show the same calculation for the period 2022-2027.

We then allocated these amounts to the institutional sectors concerned. This is the only treatment carried out here. We have attributed actions relating to the environment to the General Governments. This is based on the fact that most of the expenditure is likely to have been on hydromorphology (as suggested by estimates for the following period), which may fall within the remit of government departments. In reality, this choice is made by default because there is a lack of clarity regarding the legal and historical responsibility for the degradation of hydromorphological conditions (see discussion in this chapter). Everything to do with sanitation is transferred to the public authority account. Only non-collective sanitation is linked to Households, which are effectively obliged to carry out this type of work. Industry and agriculture are naturally included under Non-Financial Corporations.

²⁰⁴ Corresponds to part of phase 6 in the CARE model (structuring of the General Ledger, monetary proxies for biophysical accounting).

Table 44 Estimated cost of achieving good ecological status (source: SNWA)

Domain	Type of measures	MP good status 2022-2027	MP good status 2016-2021	Responsible sector
Environments	Total	1005		
	Continuity	640		
	Morphology	335		
	Wetlands	30		
Sanitation	Total	3985	4 310	
	Wastewater treatment plants	370	1 390	GG
	Networks	1250	1 550	GG
	Rainwater	1900	900	GG
	Non-collective sanitation	465	470	Households
Industry	Total	380	550	NFC
Agriculture	Agroecology (AB, grasslands and hedgerows)	7510	9 340	NFC
<i>Direct debit</i>	<i>Water efficiency (local authorities and industry)</i>	320	170	<i>Excluded from the analysis</i>
TOTAL		13200	15 020	

Legend: in millions of euros; MP stands for Measure program; AB stands for organic farming.

3.1.3.2. Estimated preservation expenditure to pay off the debt

The SNWA's accounts show the environmental expenditure actually incurred. The total amount of the subsidised project is indicated for each subsidy awarded. As with the subsidies, the allocation of the project by sector of activity is done by mentioning the NAF code of the organisation that received the subsidy. The same adjustments are made in the case of a player not directly involved in the environment (ASP, etc.).

The actual expenditure is recorded in the accounts anyway, as it is linked to a transaction. However, to know whether it can be taken into account to reduce the amount of ecological debt, it is necessary to demonstrate that it is effective. It has not been possible to do this. We will therefore limit ourselves to presenting the amount of reclassified projects.

3.2. Results - Monetary accounts

Table 45 shows the amount of ecological debt contracted by the various institutional sectors. Only the liability account is shown, but it gives rise to the recording of an equivalent amount as an asset in the "Nature" sector. It can be seen that Non-Financial Corporations have the highest amounts of debt, which is mainly due to agricultural pollution (and therefore the efforts required to change practices). This is followed by General Government, which is responsible for most of the pollution from Households (which passes through wastewater networks). Another reason for this high figure is 'rainwater', i.e. all the water that runs off man-made surfaces (roads, roofs, pavements, etc.) and is loaded with pollutants.

Table 45 Ecological debt for water bodies

Balance sheet						
Total	Nature	HH	SNWA	GG	NFC	Liabilities
						Financial liabilities
14 850 €		1 860 €		3 100 €	9 890 €	Ecological liabilities - Water bodies

The result of the reclassification of subsidies by functional type and institutional sector is shown in Table 46. Water charges are also broken down to provide a point of comparison. The total of water charges and subsidies can be seen in the SNWA column, which we have isolated from the rest of General Government. Total subsidies are shown in the "Subsidies" line. The following lines detail the different allocation items according to the typology we have created.

Table 46 Monetary current accounts

CURRENT ACCOUNTS								
	NFC	GG	SNWA	HH	NPI	Unknown	Nature	Total
Operating account								
Remuneration								
Taxes (water fees)	- 428,0 €		4 631,0 €	- 4 203,0 €				- €
Grants	668,8 €	2 185,2 €	- 2 962,8 €	6,1 €	102,4 €	0,2 €		- €
Classic grant	143,1 €	158,2 €	- 319,3 €	0,0 €	18,0 €	- €		- €
Environmental activity support grant	9,7 €	117,8 €	- 170,9 €	0,0 €	43,4 €	- €		- €
Monitoring grant	9,5 €	23,6 €	- 34,0 €	0,0 €	0,9 €	0,1 €		- €
Avoidance grants	216,6 €	26,7 €	- 255,7 €	2,4 €	10,1 €	- €		- €
Preservation grant	265,6 €	1 808,8 €	- 2 100,2 €	3,6 €	21,9 €	0,1 €		- €
Unknown	24,4 €	50,1 €	- 82,6 €	0,0 €	8,1 €	- €		- €
EBITDA								

Households are the biggest contributors to water charges. The charge is based on the water bill, not on pollution or other impacts on the environment. The primary aim of the charge is not to pay off ecological debts in accordance with the polluter-pays principle.

Subsidies granted by the SNWA are mainly directed towards General Government, for conservation actions. The largest item (€1.7 billion) corresponds to wastewater treatment, in the form of preservation and reduction subsidies. This mainly involves water treatment and network maintenance. This is followed by expenditure on hydromorphology, which amounts to nearly €130 million.

The next largest subsidies are those awarded to non-financial companies for conservation or avoidance. Almost all of the avoidance subsidies go to farmers, to the tune of 210 million euros. Preservation subsidies are those awarded to industry for water purification.

There are also 'traditional' subsidies, amounting to €143 million for the private sector and €158 million for public authorities. These mainly comprise subsidies for drinking water purification, and a more marginal amount for the protection of water catchments.

Since the SNWA database indicates the total amount of the subsidised project, we can reclassify them using our typology of activities. However, the data did not include any standardised information as to whether they were asset acquisitions (Gross fixed capital formation), current expenditure (Intermediate consumption), property transfers, etc. It is therefore not possible to classify real

preservation expenditure correctly in the Sequence of accounts. We therefore present only *total expenditure* in Table 47.

Table 47 Environmental expenditure related to SNWA subsidies

	NFC	GG	SNWA	HH	NPI	Unknown	Nature	Total
Post-grant expenditure								
Non-environmental expenditure	447,4 €	487,3 €		1,4 €	41,6 €	- €		977,8 €
Other environmental expenditure	23,3 €	256,2 €		0,1 €	110,9 €	- €		390,5 €
Monitoring expenditure	57,1 €	125,2 €		0,0 €	4,6 €	0,5 €		187,3 €
Avoidance expenditure	470,6 €	41,3 €		6,1 €	22,1 €	- €		540,2 €
Preservation expenditure	724,2 €	4 980,3 €		5,7 €	79,5 €	0,4 €		5 790,0 €
Unknown	56,0 €	113,7 €		0,0 €	15,4 €	- €		185,1 €
Total	1 778,5 €	6 004,1 €		13,3 €	274,1 €	0,9 €		8 070,9 €

These amounts are globally proportional to the subsidies. As subsidy rates are confidential, it is not possible to go into further detail.

4. Discussion

4.1. Feedback on the compatibility of Water Agency data

4.1.1. Limitations of the technical work carried out and prospects for improvement

The quantitative aspects could not be dealt with in this chapter due to lack of time. This would have been particularly interesting, as it is one of the main aspects that has historically led to the introduction of water policies in many countries, particularly in the Mediterranean. It would seem possible to create ecological debts on this dimension of water bodies, but this would require taking perimeters that are different from water bodies. Water abstractions and discharges often take place in very different places and often in different bodies of water. It would therefore be necessary to define ad hoc perimeters, including the bodies of water at the entry point of the small water cycle and at its exit point, as well as the intermediate bodies of water between these two entry and exit points, because they are affected by this loss of water from them.

Hydromorphology, and in particular the question of ecological continuity, could only be partially addressed due to a lack of data. This aspect is included in the monetary accounts. It has been used to allocate the monetary debts estimated by the SNWA. Subsidies relating to this aspect (elimination of structures, remeandering, etc.) have been the subject of our own reflection in order to classify them correctly. However, this aspect of ecological status is not covered in the biophysical accounts. As this dimension is only used to pass from good to very good status under the rules of the WFD, it was not necessary to mobilise this data to estimate the biophysical debt. Even though hydromorphology has a definite effect on biological indicators, the lack of information to make this link again prevented us from taking it into account. Finally, on the assets side, there was no data on who was responsible for the deterioration in this dimension.

With regard to the creation of the table of biophysical assets, it should be borne in mind that there is no rigorous link between the allocation we have made and the quantity of pollutant actually emitted, nor with the ecological status of the water bodies. The orders of magnitude and relative contributions therefore seem valid. If we still wish to approach a rigorous ('scientific') version of the polluter-pays principle, there are two possible areas for improvement:

- With the quantity of emissions per player or per sector, it is possible to better represent responsibilities. The individual approach, while appearing more rigorous, requires a lot of data. A less detailed approach is possible, by reworking the emission values for Households, agriculture, industry, etc., which can be found in the assessments of the catchment area. However, the case of diffuse pollution poses even more problems, as the "actor-emission-impact" chain is extremely difficult to trace completely.
- As regards the contribution of pollutants in relation to each other, the quantities of pollutants can help, but are not necessarily sufficient. Indeed, there are threshold effects and interactions between pollutants that imply non-linear relationships between these quantities and the biological indicator parameters on the one hand and the ecological status on the other.

In the next sub-section, which discusses the allocation of responsibilities, we will see why the allocation we have made may be acceptable under certain very specific conditions (even if they are rare).

This exercise was not entirely successful. The economic data produced by INSEE could not be used to fill in the many gaps in the table we produced (production accounts, redistribution, consumption, assets, etc.). This work could be carried out by taking data from all the establishments present in the communes of the catchment area. Similar work has been done for the Water Agency in the past, which indicates that it is possible. It should be borne in mind that the interpretation of aggregates derived from National accounting on a sub-national scale is always open to question.

Even so, this work has great potential. It would make it possible to compare ecological debt data with all the other economic accounts. It could yield a wealth of information that would be of great interest in discussions on water policy. For example, each sector's capacity for financing and action, the contribution of charges and subsidies to the sector's overall economic performance, the ability of sectors to repay their ecological debts on their own, an analysis of the potential for efficiency in subsidies, the share of environmental assets in the business models of the different sectors, etc.

4.1.2. Discussion of agreements adopted

In this section, we look at the different alternatives we were faced with in constructing the accounts. We compare them and justify our decision. This will be an opportunity to discuss the different anchors for the conventions chosen.

4.1.2.1. Definition of capital

The choice made here is to describe the bodies of water in themselves, by means of a set of characteristics that are specific to them. The aim is not to describe them in terms of the services they provide. What's more, these are indicators of state or stocks (concentration of pollutants in the environment, number of species present, etc.), not annual variations or flows. This avoids the problem of *baseline shifting*.

To define the capital and choose the indicator to characterise it, we had three possibilities: 1) the river basin (possibly the country or even the EU), with the number of bodies of water in poor condition as the debt indicator; 2) the definition we have adopted, i.e. the body of water as the capital, and the number of classes of condition to be improved for the debt; or 3) using the indicative parameters (pH, pollutant masses, biotic indices, etc.) of the Water Act, and defining a capital from these.) from the Water Act, and define a capital based on these.

This third choice might have seemed logical. In fact, at the finest level, conservation actions to reduce the impacts or restore aquatic environments must bring about changes in pH, the Indice Poisson en Rivière (IPR), pollutant concentrations, and so on. We might therefore be tempted to define ecological debts in these terms. We would then see biophysical debts appearing under the headings "Water bodies - pH", "Water bodies - IPR", "Water bodies - Nitrates", and so on. This choice would give a detailed view of ecological issues. It has the advantage of being highly operational, by directly explaining the connection between the level of ecological debt and the conservation expenditure that reduces the corresponding debts. However, using the indicative parameters in isolation from each other to define debts contravenes the logic defined in the regulatory texts. In fact, this would be to deny the concern for preservation, which does not relate directly to these characteristics, but to complete bodies of water. This aspect is explicit in the texts, and it explains why aggregation rules

between indicative parameters are defined to calculate the overall status of water bodies.²⁰⁵ These parameters are only summaries; they are certainly useful, but their only purpose is instrumental.

The choice of centring accounting around the water body, apart from stemming from our interpretation of the law, seems to us to have several advantages. Bouleau and Deuffic (2016) indicate in particular that water bodies are "elementary units of management and reporting [...], which must be homogeneous from the point of view of pressures and grouped by type according to ecoregions to be defined on the basis of natural characteristics (flow, geology, altitude...)". So, in principle, they combine important ecological characteristics with being a management unit. From an accounting point of view, such a definition of capital makes it possible to aggregate the state of different bodies of water by sums. Thus, by means of a simple calculation that does not alter the individual definition of capital, we can obtain a more global vision, on the scale we want. If, on the other hand, we wish to better understand the evolution of a particular debt, we can have a more refined vision by simply going back to the source data corresponding to the status of the indicative parameters.

The last possibility would have been to use the SNWA's management tools as a starting point, and to consider as an indicator the number of bodies of water in good (or less than good) condition. In this case, the capital defined would no longer be the body of water, but the river basin. We would then consider that this basin is described by the state of its constituents, the individual water bodies. Although this would entail fewer upheavals for the SNWA, we felt that this choice was slightly out of step with the concern to preserve legislative texts. It is, however, the only point that seems to oppose it. That said, we need to be aware of the difference between the two points of view: the number of bodies of water in good (or less than good) status masks the amount of effort that needs to be made to achieve good status. The number of status classes provides more information from this point of view (this point needs to be qualified, as most bodies of water are in average status, which is certainly linked to the rules for calculating ecological status).

4.1.2.2. *Choice of statistical unit*

As we have seen, the statistical unit used is the institutional unit. It therefore refers to actors and not to the ecosystems themselves (water bodies, wetlands or sub-catchments). This is a different choice from what is usually done in the biophysical information systems of the SNWA, in the statistical services of the ministry in charge of the environment or in the SEEA EA (United Nations, 2021). This choice is consistent with the National accounting approach, which aggregates individual accounts ("micro" level) where they exist.

4.1.2.3. *Liability and assignment of debts*

From a constructivist perspective, the question of responsibility can be dealt with on the basis of three elements: the law, which represents the formalised side of the question and which is 'solid'; the financial aspects, which in this case are nonetheless partly framed by a softer law to which the SNWA and the players who interact with the environment are subject. This reflects a vision of things that is not as formalised as the law. Finally, actual management is an informal vision of responsibility.

In France, water policy is the result of successive additions of environmental dimensions (point source pollution, resource management, emergence of diffuse pollution, ecosystem management, continuity management, spatial management). This leads to different treatments of responsibility. Historically, a

²⁰⁵ It should be noted that there is another problem with using such precise elements in business accounting (according to the CARE model): if this information were to be published, it would reveal a great deal of information about the company's business model. Some 'blurring' of the information is preferable. But this point deserves more discussion.

system of cost-sharing has been put in place, based on the principles of the levy-payer (for quantitative aspects) and the polluter-pays (for pollution), which are relatively well respected. As far as point source pollution is concerned, the legal responsibility of those involved is clear. With the emergence of the issue of diffuse pollution, this aspect is being called into question: farmers are in fact much more responsible for pollution than their charges (and what they receive) or the law would suggest. In the accounting above, we propose to return, as far as possible, to a representation that respects the polluter-pays principle. But in the absence of law and a suitable management system (we could have allocated responsibilities on the basis that charges are 'well' distributed), what basis should we choose?

In the biophysical accounts, where we deal with the issue of **point-source and diffuse pollution**, the solution adopted is imperfect because of the data available. Despite our efforts to go back to the sources of pollution, the allocation of assets is not rigorously "scientific" and perfectly satisfactory from an intellectual point of view (see previous sub-section). The lack of data is real and can be overcome for point source pollution, but the case of diffuse pollution may not be resolved at a reasonable cost. If it proves impossible to obtain satisfactory data in the long term and this choice has to be defended, the allocation of assets made here could also be seen as falling within another field relevant to accounting. It is that of managerial pragmatism, of the "useful" convention (Desrosières, 2010, p. 446, 2008a, p. 104). The figures in this table should be seen not as a representation that strictly complies with the polluter-pays principle, but as a *conventional* allocation of responsibilities and their origin for specific purposes. In this way, the accounting convention would take precedence over the legal or fiscal concept. The scope of the uses of this information would certainly be reduced and open to criticism, but this would not necessarily mean that it would be null and void. In certain arenas, it could serve as a basis for discussion and decision-making. It should be borne in mind, however, that the division of responsibilities would be turned on its head: based elsewhere on the tonne of pollutant emissions, it would be based here on the mere presence of a player on a body of water. In general, there seems to be little resistance to criticism of this convention. That said, in some cases it may be sufficient. For example, when discussing the aggregate responsibility of institutional sectors. At such a macro level, action is not necessarily hampered by this blurring of information. So it would still be possible to use this table to analyse the broad masses, target subsidies, etc., bearing in mind that this can only be done on a macro scale and that players acting at lower levels of organisation will have to "adjust their aim".

In another area, that of **ecological continuity, which** we studied for the monetary accounts, the accounts highlight the vagueness that exists as to who is responsible for what. The issue of removing barriers to ecological continuity raises questions: while these weirs and dams were not considered environmental problems for a very long time (they were even encouraged at certain periods), they have now become so. Since then, a system for sharing costs has been put in place, with part of the fees being recycled to manage these works. Other European countries have not made this choice and have preferred to focus their efforts on other aspects of watercourses.

If we take the example of the department, used as an illustration above, there are two possible treatments (Figure 45)²⁰⁶. We can consider:

- that the debt of the owner of the micropower station (he is clearly identified here) is transferred to the département (through a legal or contractual channel) and that the département receives a

²⁰⁶ If there is no intermediary (such as the département here), the subsidy paid directly to the owner corresponds to case 2 of Figure 45. This is because it is not possible to transfer the debt to the SNWA; if we did, we would no longer be able to justify the subsidy to the owner.

subsidy from the SNWA to help it settle the debt. A simpler approach would be for the debt to be recorded directly by the département, without it ever appearing on the owner's books. This is what should be done if the owner of the structure cannot be identified. In these two situations, the aim is to pool the ecological debts linked to the break in continuity at the level of the département.

- Or the debt is contracted by the owner of the micro-power station, but its *repayment* is partly mutualised²⁰⁷ at the level of the river basin (by a financial channel only): in this case, the département receives a subsidy to subsidise the owner;

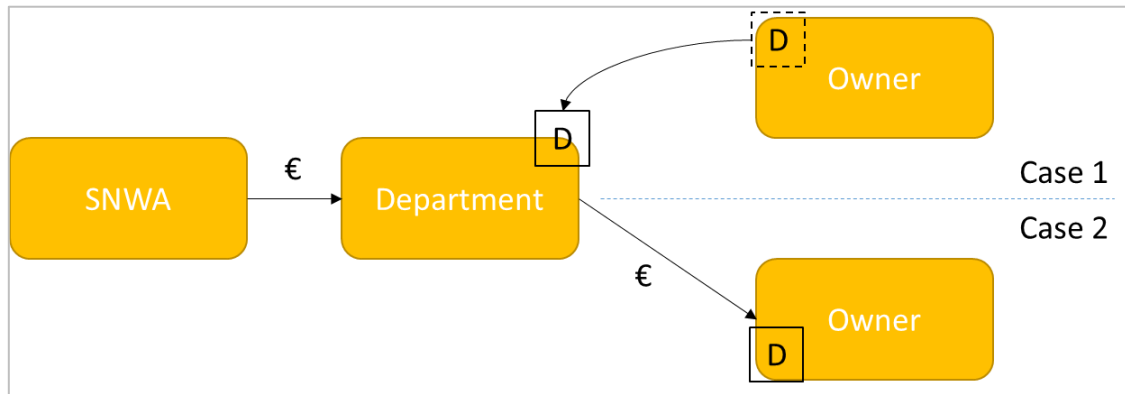


Figure 45 Two possible treatments for debt (D) at micro level

Although we indicated above that we had attributed monetary debts to General Government, in reality we were unable to make a rigorous decision on this point. Neither legal responsibility nor the sharing of the cost are explicitly mentioned in the documents to which we had access. So, officially, we don't know who is responsible for what. The SNWA has confirmed that the management of these structures is not subject to law, and that it is necessary to refer to practice on a case-by-case basis. (Feuillette and Clerc, 2022). From the SNWA's point of view, these two treatments are equivalent in any case: the expenditure cancels a debt, whether or not it has been transferred to the département. If we wish to construct a National accounting system based on more detailed data, we would have to address this issue. This would enable us to record the various flows between administrations.

4.1.2.4. Summary: the different bases of the agreements selected

Finally, we have chosen conventions that are based on the two pillars that give legitimacy to National accounting: science and the State. (Desrosières, 2008a) (Table 48). We thus rely alternately on scientific expertise and the law, but also on existing accounting categories and on the more or less formalised arrangements that the players find among themselves. From the verbal definition of preservation concerns in the WFD and LEMA to the monetary debt figure, a number of translations have been made, by ourselves or others.

²⁰⁷ This is known as "socialisation" or "mutualisation", because polluters do not pay a fee commensurate with their impact. Thanks to subsidies, costs are deliberately shared between users, even though we know who the polluters are.

Table 48 Anchors used to select accounting policies

	Origin of choice	Objectification regime
Choice of statistical unit	System of national accounts	Accountant
Accounting structure	Environmental accounting; System of national accounts	Accountant
Definition of water bodies (scope, status, thresholds)	WFD, LEMA, decrees, state of play	Scientific expertise and law
Allocation of debt and assets (liabilities)	SNWA data and legislation	Management situation; law (marginal)
Type of subsidy	CARE model; System of national accounts (at the margin)	Accountant
Monetary valuation of ecological debt	SNWA estimate	Scientific expertise

To begin with, the **accounting structure** has three origins: the Unpaid Ecological Costs model (Vanoli, 2017) and a translation of the CARE model (Rambaud and Feger, 2019; Rambaud and Richard, 2015) into National accounting (Chapter 4). The main principles of Unpaid Ecological Costs and the CARE model are similar (Chapter 1). They share a certain vision of the relationship between the economy and ecosystems (which can be summed up in terms such as strong sustainability, relational ethics, non-instrumental ethics, etc.) that are reflected in a number of design choices. However, we do not use either of them exactly, because we need to adapt and refine Vanoli's model, and adapt CARE to the principles of National accounting.

The **definition of water bodies** (perimeter, status and preservation thresholds) and, consequently, the impacts they suffer, is based on European and French law. These are themselves a mixture of science (through the expertise that has been mobilised) and the creation of standards through a more political process. This involves negotiations between the stakeholders - "government delegations, national experts and European officials" (Marchal, 2020) - to define the status of bodies of water, resulting in "decisions [that] are based more on a weak consensus between stakeholders than on scientific rationality alone" (Marchal, 2020).

As we were unable to find all the elements required for our accounting proposal in the officially accepted standard, we had to rely on current practice. SNWA management tools (data, typologies) were used. We used the typology of pressures developed by the SNWA and linked these pressures to institutional sectors. This made it possible to estimate who generated the debts. However, an additional layer is required to classify ecological debts correctly in the accounts: law, tax law and practice.

Turning to monetary accounts, new aspects emerge. IS the amount of subsidies is not very controversial (because their valuation is based on accounting evidence, which attests to the transaction), but the construction of the new typology of subsidies is open to discussion. We have also departed slightly from the CARE model to add the notion of "production of environmental goods", which is an activity that benefits the environment but is not linked to a debt. This idea comes instead from National accounting (United Nations et al., 2011).

Finally, the element that is certainly most open to discussion at this stage is the monetary estimate of the debts. Here, the figures come directly from the work of the SNWA. We have used them to illustrate

our point, without discussing the conventions adopted to estimate their amount. These are very important, however, and can vary the amount of debt considerably.

4.2. What micro-macro links are emerging for water accounting?

4.2.1. Conceptual coordination and construction of multi-scale information systems

In the case of water policy, it can be seen that there are a number of linkages, some of which differ from those used in economic accounting (Figure 46).

As far as the conceptual aspects are concerned, it can be seen that the regulations in force divide water systems and aquatic environments into water bodies, which is a relatively fine level, but without going as far as describing an individual capital (the leftmost part of the diagram). Figure 46). The body of water, the entity to be preserved, is in fact managed by several players. This has not always been the case: the 1964 law divided the system into *river basins*, which encompassed even more individuals interacting with the system. Note that the arrow is double, which reminds us that water policy was built on national or even territorial bases, which existed previously (Barraqué and Laigneau, 2017; Bouleau et al., 2017; Marchal, 2020). However, it can still be said that water policy is essentially *top-down* because the WFD definitions are strict.

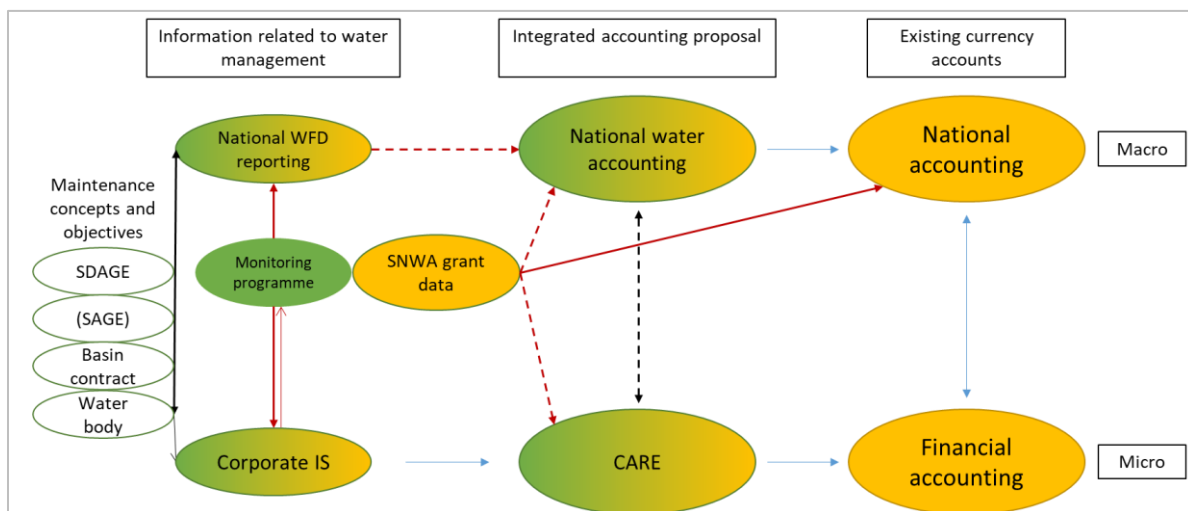


Figure 46 Micro-macro articulation of (proto-)water accounts

Legend: the green and orange colours indicate the biophysical or monetary nature of the information; black arrows: links relating to conceptual exchanges; red arrows: data exchanges; solid arrows: relationships or exchanges existing today, the thickness indicates the strength of the link; dotted arrows: links discussed in this chapter; blue arrows: elements discussed in other chapters. IS = Information System.

In parallel, preservation thresholds are successively described (Figure 44). We have described them in a separate section to show more clearly that the administrations that define them are not exactly the same as for the capital ontology, which is more the responsibility of the European Union. But in reality, these thresholds do form part of the ontology of water body capital. On the other hand, as soon as we reach the level of the water body, we see that more often than not it is several individuals that interact with it. So, in order to guarantee the good ecological status of the entire body of water, in principle everyone has to share out quotas, objectives and individual limits on pollution or degrading uses.

Finally, here, the micro-macro link operates in several directions. In the top-down direction, the regulators divide up an ecological system (the catchment area) down to a fine level. The regulators'

action stops there. The users of a body of water then have to share out/allocate impact/use quotas. We therefore move from the macro-system (the European Union) to the mesosystem (the body of water) by *division*, while collective management starts at the level of the body of water and reaches the individual by *distribution/allocation of objectives*.

As far as **data exchange** is concerned, it has been noted that data comes from the field to feed a national and then a European information system. On the other hand, unlike economic information, which is collected at the level of individuals, environmental information comes from the bodies of water themselves, from observations of the environment. The information system is therefore largely built and updated by General Governments. Only a small part of the information system comes from data from economic players (origin of pollution). In addition, most of the monetary data comes from the Water Agency. A small supplement (which we did not use) comes from the Ministère de la Transition écologique survey of environmental expenditure by individual players. It should be noted that the subsidy data from the Water Agencies feed into the National accounting system, but that in this system, the agencies are considered as 'micro' players, contrary to what appears in our diagram.

Our accounting design work has led us to propose a structure that is largely based on what already exists. However, there are several new features. The first, at the macro level, is to ensure consistency between biophysical reporting on water bodies and National accounting. This point is discussed above.

Secondly, the choice to have an accounting system that involves a "meso" level bringing together several players around the bodies of water is not just opportunistic. We believe it is justified by the nature of the (ecological) systems represented. As we saw in the introduction, aquatic systems are complex systems. Their responses cannot be understood solely by studying the points of impact (positive or negative) on the ecosystem. It is also necessary to have a vision of the complete system and its response. This is particularly the case for diffuse pollution (the origin of which is sometimes only presumed) or disruptions to ecological continuity, which also require the response of the environment to be measured. Ecological accounting should therefore take on board the (micro)-meso-macro organisation of existing information systems on aquatic environments. A micro-macro link cannot suffice, unless we ask the players who cause the impacts to also collect information on the reaction of the environment, the effects of thresholds and the storage-release of pollutants, etc. This would require measurement efforts that would not be sufficient. This would require measurement efforts that go well beyond their usual management perimeter and resources. In addition, given that it is not always possible to disentangle the responsibilities of each party, it would be very difficult to apportion the costs of data acquisition.

Finally, it seems necessary to make two innovations concerning economic data: the first consists of fully integrating them with data on the state of and pressures on water bodies. We have done this to some extent, but many subsidies cannot easily be channelled to a specific body of water because they are channelled through intermediaries at higher levels. Resources allocated to certain bodies of water by other players are also missing. Furthermore, it would be conceivable for anonymous and standardised information on the cost of reduction and restoration projects to be made available to stakeholders upstream of development and discharge projects in order to estimate their ecological debt.

To conclude this sub-section, it is important to note that the macro level of BAs is very similar to the macro level. Figure 43, Figure 44 and Figure 46 is not of the same nature as that which would be defined for "climate capital (Rambaud and Chenet, 2020). This is because water bodies are entities with a sub-national perimeter, whereas the climate is global. So what we are talking about here at macro level is in fact a territory that brings together several capitals (bodies of water). For climate, on the other hand, the macro level would represent a virtual division of the atmosphere in order to attribute part of the greenhouse gas emissions to a country. Here, European or French 'water', as referred to in the Water Framework Directive or in French law, only makes sense as a relatively virtual entity corresponding to the union of bodies of water, which are the real capitals²⁰⁸. From this point of view, European or national water is in fact an area of equivalence (Desrosières, 2008a, 2008b) bringing together numerous bodies of water for the purposes of uniform management (comparability of their states, funding, etc.), but it is not a single ecological system.

4.2.2. Are the different approaches to National accounting and water management a hindrance or an advantage?

National accounting adopts an individualising, homogenising and sectoral point of view, whereas water management may seem more collective, contextual and territorial. These apparent differences in logic are worth examining.

National accounting for the environment, through the concept of debt or the statistical unit of reference, naturally shifts the focus back to the individual: who generates the debt and the impact on the environment? Who is responsible for it? Who will pay? Who benefits from additional resources? This tendency towards individualisation is common in economics (which adopts a methodological individualism) and law. However, it clashes with the usual practice of ecosystem management, and water management in particular: we talk much more often about landscapes, territories and common goods. The Water Agencies are the embodiment of a mutualist management of water, almost as a common good (Barraqué and Laigneau, 2017). It is therefore largely collective. This is clearly seen in the organisation of plans and contracts, which are very formal up until the river basin contract, and less so thereafter. The transition to the individual is much more a matter of negotiation than of a state "command and control" system. Practical experience shows that refocusing points of view on individuals often blocks the discussion, and that we quickly revert to "us", "them", "them", etc. (Bouni and Dufour, 2004). (Bouni and Dufour, 2022). Going back to the individual, especially in a context where the pooling of resources is well established, breaks social peace by calling consensus into question.

To respond to this, we can begin by qualifying this statement. The conceptual framework of the National accounting tends towards individualisation, but the individual as such is first and foremost a statistical unit that is useful for constructing the information system. When all is said and done, the information provided submerges the precise role of each individual in global aggregates, possibly sectoral aggregates, but we never completely return to the individual level. It should not be forgotten that National accounting allows a "policy of large numbers", not of individuals.

²⁰⁸ We have adopted a point of view similar to that which consists in defining a posteriori the entity France as the place where the French live (themselves having an essence of their own, which the country, which is merely a union of individuals, does not have). But we could have taken the opposite view. Just as French individuals can be defined as those who live within the geographical perimeter of 'France', we could have considered bodies of water as instances of European 'water'.

Secondly, although accounting "lays bare (Bouni and Dufour, 2022) by revealing (even in aggregate) their economic characteristics, the stakeholders are rarely completely unaware of each other's constraints and possibilities. No one is entirely fooled by the apparent mutualisation, and everyone is well aware of their gains and losses in the deal. In reality, accounting (and this feeling of individualisation) is above all difficult because it forces us to discuss the distributional stakes (who will win, who will lose?) and the means of achieving (or not achieving) results on a solid basis. (Feger and Mermet, 2018; Mermet, 2011). The hard points that are essential to unblocking a situation and creating change are laid bare. If such accounts were to be created, they would certainly reveal and therefore clarify situations. The State could seize this opportunity to target aid more effectively, for example.

Then we come to a second aspect: National accounting, like economics, adopts a point of view which, *a priori*, considers behaviour to be homogeneous. In effect, the accounting categories are the same for everyone. Of course, *a posteriori*, once the categories have been filled in, heterogeneities emerge between sectors and branches of activity. But once they have been grouped together in the same category, the specific characteristics of the individuals in that category disappear. (Bouleau and Deuffic, 2016; Desrosières, 2008a) and everyone is supposed to operate according to the same programme (Morin, 1980). On the contrary, action, and hence water management to a large extent, is based on contexts, in which individuals with *strategic* behaviour interact (Morin, 1980).

Once again, a large part of the resolution of this apparent conflict depends on the scale at which we view things. The higher the point of view and the greater the number of individuals involved, the less awkward it is to consider them in the same way. This is true as long as the description is at least operational, particularly with regard to the capacities for action of the person using it (calibrating fiscal instruments, estimating whether a country is achieving its quality objectives, and therefore whether European funding is required, etc.).

Finally, as we have seen, it is a sectoral vision that is being proposed, rather than a territorial one. And yet the territorial dimension is at the heart of water policy. The various committees are based on hydrographic basins, major sub-basins, catchment areas and bodies of water, where the management, ecological and human issues are relatively homogeneous. Concealing this aspect may seem problematic. To this we can reply that up to a certain point it is possible to break down National accounting by territory. But the finer the breakdown, the less relevant the figures produced.

That said, the sectoral dimension is far from absent from this policy. Basin committees are made up of representatives of economic users (agriculture, industry, freshwater fishing, aquaculture, tourism, electricity producers) and non-economic users (water consumers, environmental associations, nautical activities, hunting and leisure fishing, etc.), as well as local authorities and the State. In the end, we find all the institutional sectors of the²⁰⁹ accounting system. Thus, the representatives can be perfectly identified with the economic figures and quantifications proposed. This type of accounting would then enable discussions to be broadened to include information on the economic health and functioning of

²⁰⁹ Discussions with the SNWA and the Ministère de la Transition écologique have shown, however, that the Non-Financial Corporations sector is divided instead between agriculture, industry and "domestic production activities" (APAD; broadly corresponding to urban convenience stores). This redistribution does not pose a major problem for the NA, but needs to be done for sub-national uses.

the various sectors: in particular, which sector saves how much? Does an autonomous financing capacity exist to repay ecological debts, or do we need aid or transfers? By comparing so-called "non-financial" assets (machinery, etc.) with natural assets (uses that degrade the environment), we can quantify how much of a sector's GDP comes from environmental degradation. This would justify helping the sector to make a transition, to reduce its environmental footprint or to offset these negative effects. All these discussions are already taking place to a greater or lesser extent, but accounting not only provides tangible elements expressed in a common language, but these elements are also quantified.

Finally, far from coming into sharp contradiction with the logic of water policy, it reveals, quantifies or puts back on the table aspects that are sometimes set aside because they are difficult (individualisation, responsibility, efforts to be made). Accounting can also complement the point of view (sectoral vision that considers homogeneous behaviours, beyond territorial and contextual differences).

4.3. What are the prospects for the use and institutionalisation of this accounting system?

To fully answer these questions, a proper diagnosis of the interplay between players and an analysis of strategic environmental management are required. (Mermet, 2011) would be necessary. Accounting in general, and the conventions adopted in particular, introduce differences in perception that are reflected in the uses and discussions surrounding the object being measured (Desrosières, 2008a). So, to take this line of reasoning to its logical conclusion, we might ask what are the consequences for the management of aquatic environments of introducing an accounting system that would replace all or some of the existing management tools. If the advantages and investments required to set up this new system outweigh the disadvantages, we can be optimistic about its prospects for institutionalisation.

In this section we propose just a few avenues that could form the basis of such an analysis. We identify the water policy discussion arenas where the accounting we propose could potentially be used. This is an opportunity to present some of the advantages and limitations of the conventions adopted. Where National accounting should stop, we propose a link with another type of accounting.

4.3.1. Discussion forums where accounting can be used

The main arenas for discussion of water policy are as follows (Favre, 2022; Feuillette and Clerc, 2022). We indicate in bold those that we believe would benefit most from ecological debt accounting:

- **European reporting exercises under the Water Framework Directive:**
 - **MTE /DEB²¹⁰²¹¹ (and more marginally, MTE/CGDD²¹²) and the European Commission:** the state of play and the achievement of objectives are discussed between these two institutions. An accounting system would make it possible to compare and explain the economic reasons for not meeting targets, the efforts made by each sector, etc. Some reports, such as the

²¹⁰ Ministère de la Transition écologique. The acronym following the slash indicates an administrative entity at a lower hierarchical level.

²¹¹ Direction de l'Eau et de la Biodiversité (Water and Biodiversity Department)

²¹² Commissariat Général au Développement Durable (General Commission for Sustainable Development)

analysis of cost recovery (*see below*), give rise to little discussion or accountability, due to the lack of a robust quantification method.

- MTE/CGDD and Water Agencies: definition of methods and management of the reporting schedule.
- **Ministerial cabinet:** trade-offs between the financing needs of environmental policies. To do this, all we need to do is look at the amount of debt owed to each capital and make choices. Scenario modelling exercises could be used to estimate the effects of reducing a debt.
- **French Parliament:** creation of new water charges; various amendments that have a marginal impact (from outside) on water policy. There was a lot of discussion with the DEB at the time. Accounting would make it possible to see the contributions of each institutional sector and compare them with their responsibilities.
- **MTE/DEB, MFER²¹³ /DGB²¹⁴, and MTE/CGDD:** discussions on the evolution of the amount and the possible creation of fees.
- MTE/CGDD and MFER/DGT²¹⁵: there have been occasional exchanges on fees.
- **Interaction between the DEB and the Water Agency:**
 - **Definition of good status objectives** (in terms of percentage of water bodies in good status). Both the aggregate view and the organisation of the underlying data called for by the accounting framework can be useful in these discussions.
 - **Addition or removal of certain subsidies:** recent removal of treatment premiums and subsidies for non-collective sanitation, cessation of subsidies if the local water price is too low (a priori sign of poor management). The accounting framework encourages the underlying data to be organised in a way that can facilitate the development of arguments for or against this type of measure. On the other hand, the account sequence format is not the most suitable (because it is too aggregated).
- **Within and around the Basin Committee**
 - Preparation of the SDAGE
 - Public consultation
- **Within the Water Agency**
- Within local water commissions (SAGE level)
- Committees responsible for major sub-catchment areas (emanations of the basin committee)
- Interaction between stakeholders on the water body or at project level

4.3.2. How can ecological National accounting be institutionalised?

Who produces and publishes the accounts?

In France, water is managed rather like a common good ("patrimoine commun") and the State only acts as a "guardian", which has only recently begun to levy part of the tax. So a *national* aggregative vision is not necessarily essential. It is true that general tax issues and the legal framework for water policy require its presence. But creating an extensive information system is not necessarily a priority need. In fact, it is the Water Agencies, not the Ministry, that create and manage the most extensive information systems. One point that could tip the balance in favour of the Ministry is the need to report the results of (national) water policy to the European Union.

²¹³ Ministry of the Economy, Finance and Recovery

²¹⁴ Directorate-General for the Budget

²¹⁵ French Treasury

It is possible to imagine an organisation similar to that for reporting biophysical data. The Ministry defines guidelines in terms of the method and format of the information produced by the Water Agencies. It then compiles and formats the data for inclusion in the National accounting system. Initially, it is conceivable that this will be a satellite account published solely by the ministry's statistical service (CGDD/SDES). INSEE could also publish them in the same way as the agricultural satellite accounts. In the longer term, if business accounting standards evolve to incorporate the same structure (debt and assets, natural assets, etc.), full integration into the national accounts could be achieved.

Cost recovery analysis: a step towards the institutionalisation of ecological national accounting?

There is now a reporting exercise under the Water Framework Directive that requires information fairly similar to that found in ecological debt accounting: cost recovery analysis. This indicator was originally designed for accounting purposes and aims to estimate whether the price paid for a water service (water use using an infrastructure) covers the costs of investment and current expenditure. With the expansion of the role of water stakeholders and environmental awareness, it has been extended to "environmental" costs (Schneider et al., 2016). These include:

"Report on the recovery of costs by user category (i.e. to what extent costs are covered by the prices paid by users), including environmental costs, in particular by identifying cross-subsidies" (Ministère de la Transition écologique et solidaire, DEB, 2017).

The aim of the analysis is threefold:

- "To assess the sustainability of public services linked to water use. In this context, we talk about recovering the costs of public services,
- To assess the equity between categories of users, in the sense of the coverage, by the user, of the costs they generate, and
- Assess the extent to which the polluter pays principle is being applied by internalising part of the environmental costs". (IREEDD, 2019)

The analysis is based on the interpretation of the cost recovery rate (Figure 47).

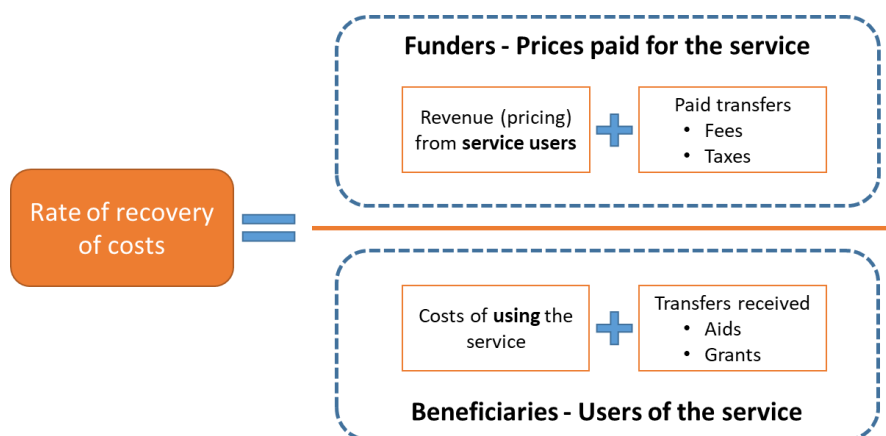


Figure 47 Principles for calculating the cost recovery rate (source: IREEDD, 2019)

An initial estimate of the rate was made at the end of the 2013-2018 cycle based on available data and sometimes strong assumptions (IREEDD, 2019). The general method (even beyond the simplifications that had to be made based on the available data) and the results were not always convincing, as the messages delivered were sometimes out of step with the Water Agencies' perception on the ground (Favre, 2022; Feuillette and Clerc, 2022).

The notion of cost is understood in a very broad sense, as all efforts and losses. This term does not necessarily have an accounting meaning, at least in the minds of the creators of this rate. However, this indicator could be derived from environmental national accounting as described in this chapter. Relatively few modifications and restatements would be necessary for this. Indeed, most of the indicator is already based on accounting data (receipts, transfers paid and received). Moreover, the data used come from the accounts of public authorities compiled by INSEE. The costs of using the service contain four categories:

- Operating costs for drinking water and wastewater services
- Consumption of fixed capital of the assets used for these services
- Environmental costs: "market and non-market damage resulting from the degradation of aquatic environments and attributable to water users. They fall into two categories:
 - **Compensatory expenditure**, which is the additional costs actually incurred by a category of user as a result of environmental degradation (aquatic environments or water resources) by another water user. For example, the relocation of water catchments or the additional treatment of drinking water required due to the presence of pollutants of agricultural or other origin;
 - **Other environmental costs**, which correspond to the damage caused to the environment by water users. They are approached at the scale of each river basin by assessing the costs of the actions still to be implemented to achieve the objectives of good status." (IREEDD, 2019).

The first two are classic accounting categories. On the other hand, "environmental costs" are of two quite distinct natures. Compensatory expenditure covers the consequences of negative externalities in the economic sense. Other environmental costs correspond in fact exactly to an ecological debt as we define it. From an accounting perspective, the term "other environmental costs" seems a little clumsy to us, as it is too general, but the fact remains that it is ultimately the same quantification that is defined here and earlier in the chapter.

The estimation of this rate, rather than relying on scattered data, sometimes produced for the occasion, could be based on an intermediate accounting level, which would combine environmental data (including monetary data) with financial data.

4.3.3. Towards a connection with ecosystem-based accounting

We have seen that water policy in France is governed by law and public policy harmonised at national level, from the establishment of standards to implementation on the ground. As some of the discussions take place at ministerial and parliamentary level, there is an interest in creating a balance sheet and national vision of this policy, in its biophysical and monetary dimensions. However, it should be noted that unlike Spain or England, where water policies are highly centralised (Barraqué and Laigneau, 2017) French policy is still essentially based on the principle of subsidiarity. This is embodied in a form of governance centred on the river basin. This perimeter places us much more on the side of so-called ecosystem-centric accounting (Feger, 2016; Feger et al., 2021a; Feger and Mermet, 2017). These are based on an ecologically relevant perimeter.

The Seine-Normandy Water Agency is particularly interesting. Indeed, the Water Agencies are the meeting point of the two levels mentioned: national and ecosystem-centric. They are relatively "macro" players and integrators in relation to the many players in the region (drawing in the national viewpoint). But they are also focused on a perimeter that is relevant to the management of an ecological issue (attraction towards the ecosystem-centric point of view). In addition, they maintain

information systems that take stock of the state of water bodies (National accounting). But they also co-construct and share a number of management tools, built *ad hoc* with stakeholders to fuel discussions (ecosystem-centric accounting). Finally, they collect fees and grant subsidies in much the same way as the State collects and redistributes taxes. However, as subsidies are granted on the basis of environmental criteria, the agency has a certain amount of influence over the players on the ground. This requires it to carry out strategic analyses to improve the situation on the ground and target actions as effectively as possible.

Being at the interface between these two levels of accounting, the Water Agency could draw on their principles to create management and balance sheet information systems.

5. Conclusion

We summarise in Table 49 the elements discussed above for the three research areas.

Table 49 Responses to the three research areas

Search gap	Issues	Answer
Attempts have been made to create accounts in France (natural heritage accounts) and abroad (SEEA water and EA), but these are not complete and do not take the form of ecological debts.	How can water policy be made accountable? What agreements should be adopted?	Feasible with a set of conventions derived from law, taxation and practice. Current data is sufficient to create a good demonstrator.
The structure of the problem and of institutionalised water management is different from that of the management of economic problems.	What micro-macro links emerge when water policy is taken into account? What is the difference between micro and macro economic accounting?	Possibly meso-macro for point source pollution Micro-meso-macro back-and-forth for diffuse pollution The logic of the NA is different but complementary. It would renew the place of certain social realities around water management.
As this accounting system is new, it is not certain that it meets pre-existing needs or that it is adapted to the way in which the players involved in this policy operate.	What are the potential uses of the accounts? Is it possible to institutionalise the proposed accounting system?	Provides refocusing that is of interest to the managers we meet. Is close to an exercise that is already compulsory, but whose method is still evolving: cost recovery analysis.

This case study shows that water policy offers a particularly interesting opportunity to construct an accounting system for ecological debts. The wealth of data makes it possible to go a long way in drawing up the accounts, at a very reasonable cost, based on what already exists. This is greatly facilitated by the current frameworks for water management, which very often coincide with those for debt accounting. What's more, institutionalising this type of accounting in the medium term is not out of the question. The exercise of analysing cost recovery, which is compulsory under the WFD, requires data very similar to that needed to construct an accounting system for ecological debts. The cost recovery rate could well become a management indicator derived from such accounting.

From a historical point of view, it is interesting to note that if our proposal goes ahead, we will have moved back and forth between sectoral and territorial approaches. In France, water policy was developed by sector (public water and sanitation services, irrigated agriculture and polluting industries) between the 60s and 90s. This can be linked, among other things, to the strong connection of the policy at the time to the Commissariat général au Plan, in the person of Ivan Chéret - the latter was a member of the CGP's water commission and the instigator of the 1964 water law (Bouleau et al., 2017)..

In the early 2000s, the WFD radically changed water management planning, moving it towards planning on the scale of the water body. Three factors are key to this change. The first is the division into water bodies. The second is the widespread use of biological indicators for many taxa, and their pre-eminence in calculating ecological status (rather than just COD and BOD, and previously a fish biotic index). The third is the introduction of performance targets for these indicators (Bouleau et al.,

2017). In particular, this made it possible to take into account the cumulative effects on water bodies (Bouleau, 2017).

On the surface, our proposal reverses these developments, offering a management tool largely structured by sector. In fact, this is not simply a step backwards, but rather an upward spiral²¹⁶. The tools used at the time, in particular the natural heritage accounts, did not go as far as fully integrating ecological issues into the economic accounts tables. Only the flow of water charges and the cost of water treatment were included. They did not include ecological debts and assets. National accounting, which takes on its full meaning when several types of players interact, is therefore in line with the WFD.

²¹⁶ Thanks to Christophe Bouni for this very telling metaphor.

General discussion

1. Reminder of the issues and approach

The research question that followed us in this thesis is: **why and how can links be made between national ecological debts and organisations?**

The hypotheses to be tested in order to answer them were as follows. The first two relate to the "why" of the problem, and the last two to the "how".

- H1 - In national accounting, the inclusion of environmental issues in the form of debts opens up new possibilities for action and makes it possible to strengthen the presence of environmental stakeholders in economic governance.
- H2 - The link between the macro and micro levels strengthens the State's scope for action, and enables economic players to coordinate to manage issues that go beyond their usual perimeter.
- H3 - Conceptually, the current environmental NA proposals can be strengthened with a view to achieving a high level of sustainability.
- H4 - Data exists to build them over the medium term while respecting statistical quality constraints.

Our workspace, described in the first chapter, was part of a triptych whose components were accounting representation, modes of action and their governance (Figure 5). At the level of the State, these components were embodied in National accounting, the uses to which NA could be put and the connection to public instruments, and finally in the democratic institutions and administrations involved in statistical production. At company level, the link was explicit with accounting, but less so with governance and business models.

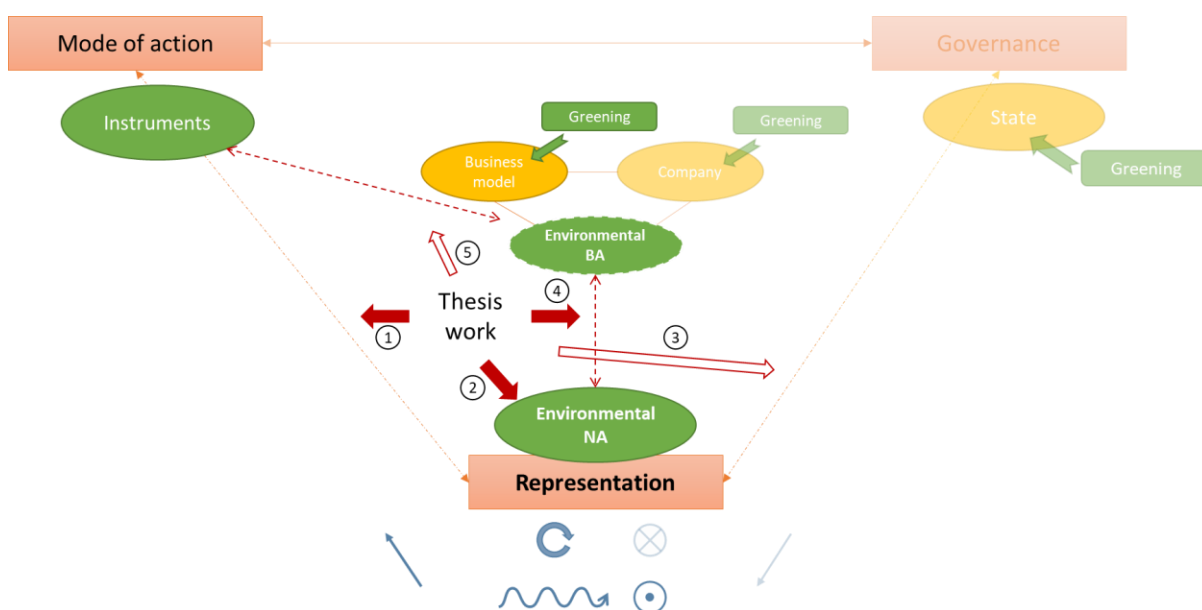


Figure 48 Green accounting workspace.

Legend: solid red arrows: subjects dealt with in depth; empty red arrows: other subjects dealt with. The blue pictograms represent the different perspectives taken to (re)work on accounting policies: the arrow on the left for the "usage" perspective, the thick arrow that closes in on itself for the "accounting constraint", the zigzag arrow for the "historical" perspective, the cross in the circle (arrow seen from behind) for the "theoretical" perspective, the dot in the circle (arrow pointing towards the reader) for the "methodological" perspective and the arrow on the right for the "governance" perspectives.

In particular, we have explored national accounting, describing how it works and trying to understand the historical and theoretical choices that have led to what it is today (Chapter 1). The link between national accounting and business accounting is described in Chapter 2. The question of its environmental extension has been closely examined through the controversies surrounding the proposals made under the aegis of the United Nations (chapter 3). The issues of use and governance are addressed in the first chapter, then the interest of ecological debt is explored in chapters 4, 5 and 6.

We studied six information systems: two economic and environmental accounting systems, at company and national level. In addition, we worked on a number of non-accounting information systems linked to public environmental policies. The links between these systems and the key issues relating to them are shown in Figure 49.

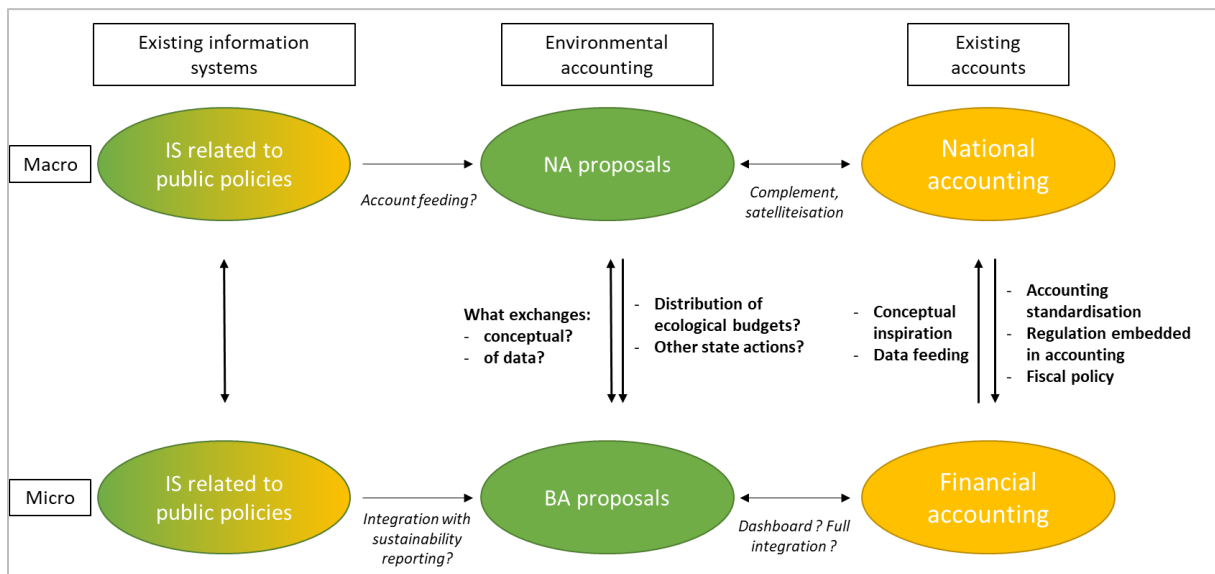


Figure 49 Articulation of the subjects studied and key questions

2. Summary of results

We have adopted three main areas of work.

The first was to analyse, discuss and design **accounting conventions** in line with the principles of strong sustainability and linked to existing public policies in order to increase the usefulness and legitimacy of the accounting thus constructed. To do this, we began by unravelling the controversies surrounding the SEEA and monetary valuation (Chapter 3). This work enabled us to respond to the criticisms levelled at strong sustainability approaches ('cost approaches' or debt approaches) and to propose an accounting structure that seeks to be consistent with the UN System of national accounts (presented in general terms in Chapter 4, with an illustration of what the sequence of accounts would look like in Chapter 5). Secondly, the work on terrestrial and aquatic biodiversity policies (chapters 5 and 6) enabled us to propose more precise conventions for representing species, (protected) habitats, (aquatic) environments and (non-artificialized) spaces in ecological debt accounting. This involved both biophysical and monetary aspects. The conceptual aspect is certainly more advanced in terms of the monetary aspects, while the application cases are probably more convincing in terms of the biophysical aspects.

So it seems that we have fulfilled the brief set by the Stiglitz Commission to design an alternative to GDP. Ecological liabilities are a scoreboard in themselves, since they bring together elements that are not directly agreeable to each other. Even if we can add up the debts, it is inconceivable, by their very nature, to substitute one for another. Our reading through the sustainability framework certainly deserves more detail, but we can see that the strong conception allows each entity to be considered for itself. The choice of dimensions is linked to the company's perception of its environment. In this way, debts make it possible to take into account a wide range of values. In addition, liabilities have a dual and highly interesting relationship with GDP: they are both the source of growth and activity, because it is here that the corporate financing cycle begins. What's more, they have to be repaid with the income generated (which is equal to GDP). Although other approaches are certainly possible, it seems that ecological debt is a good response to what should be built to "measure sustainability".

The second focus was on the **micro-macro link**, i.e. between Business accounting and National accounting. The aim was to take up the French tradition inherited from the post-war period, which consisted in building an accounting structure and an information system based on business accounting (chapter 2). We therefore translated the CARE model into National accounting, broadly following the translation of Business accounting by National accountants. The question of liabilities did not pose any particular problem. On the other hand, we had to clarify the concept of assets, as well as the place of preservation expenditure (which remains a priori in GDP). The question of the monetary valuation of assets (by breaking down preservation costs, as in the CARE model; or else, to comply with National accounting, at a possible market value which could not be clearly identified) could not be decided for the moment. This will require further work on accounting theory, and discussions with National accounting.

This work has brought to light a fundamental aspect that makes it possible to resolve the former controversy of the SEEA over the degree of reality of the accounts produced (chapter 5): for National accountants, the existence of Business accounting based on ecological debts means that these debts can no longer be modelled, but can be observed as economic facts in their own right²¹⁷. In addition to the fact that proto-ecological debts already exist in the form of site rehabilitation obligations and environmental impact assessments, we have noted that structural developments are moving in this direction through the new European sustainability reporting requirements, which will become mandatory from 2024. The proliferation of neutrality objectives (carbon, biodiversity, good ecological status) and the voluntary or compulsory enrolment of companies to meet them reinforce this dynamic by bringing the ecological entities to be managed closer to the scope of action of companies. In the meantime, it remains possible to introduce more accounting frameworks into the modelling of these debts, using an approach that we described as "economic" in Chapter 4. This would make it possible to construct more robust satellite accounts of national financing requirements.

Finally, and this makes the transition to the third area of work on the **uses of** accounting, the conceptual articulation between the micro and macro levels makes it possible to establish a dialogue between these players and to consolidate the State's means of intervention. Outlined in the first chapter, and then discussed in relation to biodiversity policies (chapters 5 and 6), these uses can strengthen the implementation and strategic evaluation of biodiversity policies themselves, inform

²¹⁷ Because of the inconsistency of the damage approach (through the value of Ecosystem services) with historical cost accounting, which is almost ubiquitous, it seems difficult to apply the same reasoning to them. The monetary valuation of these services still seems doomed to be modelled.

(interministerial) arbitration at the design stage, and feed into indicative planning to drive an ecological transition. It is possible to rely on the classic functions of accounting, which acts as a system of transparency and coordination, while providing a global vision of what needs to be managed (in this case, the economy and its relationship with the environment).

The rest of this discussion will build on these three themes by providing a more detailed summary and outlook. It also outlines future areas of research.

3. How “resistant” is the ecological debt?

Desrosières has analysed various quantifications from the point of view of their solidity in the face of criticism. It's a question that every designer must ask himself if his approach is open to challenge or if he can hope to see it adopted. He puts it this way:

"Statistical totalisation [...] is seen as involving the sacrifice of something (in terms of singularity), through conventions of equivalence and codings that are always situated, in favour of the (conventional) constitution of a new generality, consistent and useful for knowledge and for the coordination of action. This hypothesis is summed up by the question: how do you make things that hold together, in the triple sense of 'that are solid', 'that hold together' and 'that hold (coordinate) people together'?" (Desrosières, 2010, p. 446)

Since robustness is the aspect most often put forward by statisticians to talk about their product, let us begin by questioning the realism of the ecological debt (the second aspect is not really discussed in this thesis; the third is discussed later in the paper). Elsewhere, Desrosières takes up this idea, explaining that by "resistance" he means "sufficient consistency and robustness to withstand without damage various tests, transport, combinations, criticisms of conventional equivalences or borders" (ib.). Reliability [...] presupposes long chains of recording, calculation and formatting, which, taken together, may or may not arouse the confidence of society" (ib.). It is this trust that promotes these statistics to the status of "information".

The reality of statistical objects and their measurements oscillates between three poles, as described by Desrosières (2008, pp. 103-104). The first is a "**direct metrological realism**", inspired by the natural sciences, which implicitly postulates that social objects are as real, defined and measurable as the circumference of the earth or the intensity of an electric current". The second is "an **indirect symptomal realism**", derived more from the sciences of life and the human body, which sees measurements as signs, reflections and indices of supposed but unattainable realities". Finally, "**constructivist conventionalism**", influenced by law and political science, emphasises taxonomic conventions and coding operations prior to measurement. In this case, the reality of objects is linked to the extent and solidity of the social investment that results from these taxonomies and codings".

Any quantification exercise can be interpreted according to this continuum and its degree of sedimentation in people's minds. The historicity and relevance of the indicator to the economic, social or political context of the moment will make it appear more realistic. The opening up or reopening of a controversy surrounding its conception will remind us of the contingent nature of its construction.

Which pole are the ecological debts we're working on closest to?

To answer this question, we need to start with the ecological entities that we wish to preserve, and follow the translation chain that leads to the national ecological debts that are supposed to represent them. Depending on the ecological entity, this chain takes different paths that oscillate between the perimeter of National accounting (macro) and that of the company (micro). They may even go beyond the NA, for example in the case of climate. Figure 50 summarises this progression. There are three successive stages: the definition of capital, its managerial translation in the accounts, and finally the statistical summaries produced for the National accounting.

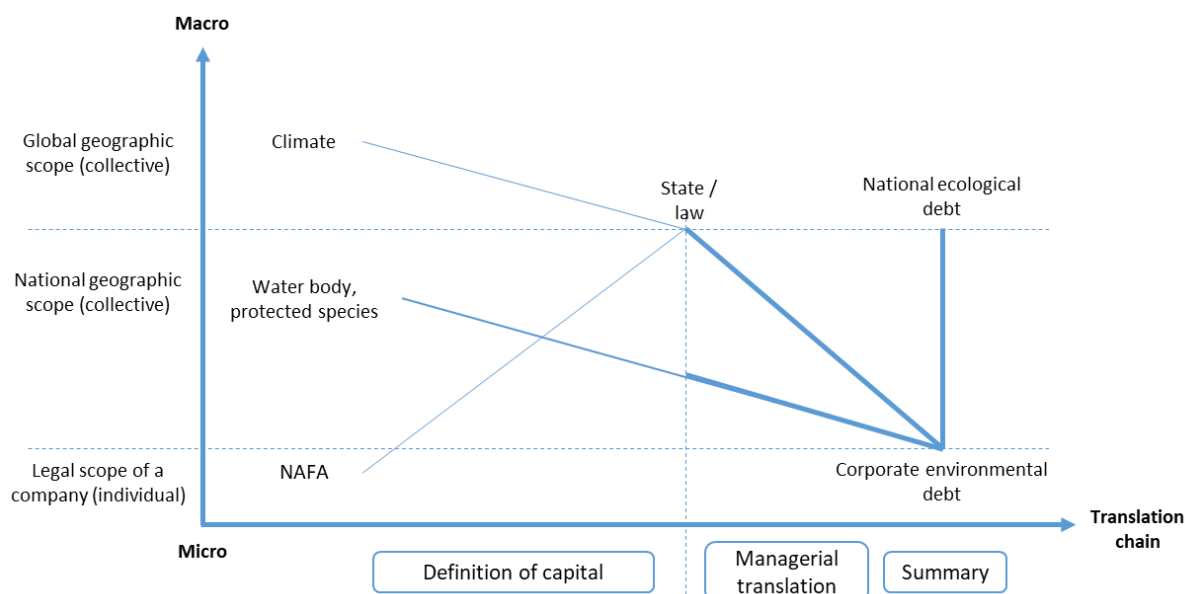


Figure 50 Translation chains and micro-macro articulation

The first consistent element of ecological debt is the definition of the entity to be preserved, using generic words, then a more precise definition and finally a representation using indicators. These indicators are based on a double operation of "convention" and "measurement" (Desrosières, 2008a). In the case of the natural capitals studied in chapters 5 and 6 (definition of conservation status, ecological status), these conventions are initially drawn from the scientific world. The categories of species or habitats are classifications, admittedly conventional, but based on criteria that are now only very marginally debated by taxonomists and botanists. We are a long way from the controversies between Linnaeus and Buffon over the definition of the concept of species (Jacob, 1970). For ordinary mortals, assigning an individual to a species is an act based on direct metrological realism. On the other hand, the way in which we define *the state* of these categories is based on *indirect symptom realism*. This is illustrated by the criticism sometimes levelled by scientists at the state of conservation (for a review, see Rouveyrol and Leroy, 2021). More generally, the endless academic controversies surrounding the definition and quantification of "biodiversity" show the diversity of possible metrics.

That said, generally speaking, the fact that conventions are enshrined in law gives them a superior resistance that cuts across scientific debates. The law is an emblematic and central place for the stabilisation of a collective of humans and non-humans (Latour, 2008). In democratic societies, the process of composition through representative bodies is rarely radically challenged. What's more, the historicity of laws ensures that conventions become sedimented in people's minds. This is an essential step in triggering action. Scientists alone cannot hope to have a lasting influence on society's destiny unless society accepts them collectively.

The further down the hierarchy of standards you go, the less resistance there is. The category of agricultural, natural or forest area (NAFA) thus comes close to *constructivist conventionalism*. It is essentially an administrative category, based on relatively weak scientific foundations, as it is linked to types of human use, and only appears in a decree. Supposed to reflect the idea of undeveloped space, it is only a useful proxy until 2030. At that point, we will have to reopen the discussion on what we accept as a definition. The definitional decree assigning extraction areas to the "undeveloped" category already shows that administrative categories, however useful they may be, are open to criticism.

The resistance of the measure that follows this agreement depends on the process implemented and the resources allocated. The status of species and natural habitats is based on professional naturalist observation networks. That of water bodies is based on a monitoring network run by the Water Agencies. Recently, there has been a national observatory for artificial development. All of them are General Government bodies subject to controls on their protocols. There is little debate about measuring the state of the environment and how it varies, insofar as the observation effort is consistent with where the figures produced are used: an aggregated or approximate view giving orders of magnitude satisfies national decision-makers, but exposes itself to virulent criticism at individual level.

In the same way, one point that may be more open to discussion is the source of the variations in the state indicators and those responsible for them. This brings us to the identification of impacts, and therefore of ecological assets. Here, public observation systems have their limits. They often proceed by more or less precise sampling. They are not always asked to establish links with economic players. We have seen that only certain *types of* stakeholder can be identified in the case of bodies of water. For protected species and habitats, only the presence of a generic type of pressure is given in the European reports. To improve on this, we have proposed basing our approach on corporate sustainability reports, which will become mandatory from 2024. Environmental impact assessments, which already exist, are another framework to be converged towards these reports, but there is still a long way to go to achieve harmonisation.

So far, despite a few points of relativisation of conventions and possible difficulties of observation, we can settle relatively comfortably into a direct or indirect realist position. Species, bodies of water and habitats seem to pre-exist the measurement, and socio-political factors only appear in the selection of the dimensions to be quantified. (Chiapello and Desrosières, 2006b). This is much less the case later on, when we move on to translation in order to reach the field of management.

Ecological debt is based on an ecological objective. Once again, this is a mixture of scientific and political considerations, which give them a particular degree of resilience. Chapter 4 looks at the different types of thresholds that can be used, depending on their origin. The SEEA EA, with a more scientific eye, provides an excellent summary of the reasons for choosing one threshold or another (Committee of Experts on SEEA ES, 2021). The inclusion of the legislative process means that the wishes of citizens and other stakeholders can be taken into account. Here, there is no perfect argument to defend one threshold or another. It is only at the end of a pluralist composition process that an acceptable threshold can be obtained. The threshold is normative, and its sole purpose is to guide action.

A final operation, which is far from neutral, is to transform the gap between the state and the chosen threshold into a biophysical debt, and then to record it in the accounts. This involves a major change

in status, which is also debatable. It is not the same thing to express a concern for general preservation in a legal text, and to place it in an accounting framework, and even more so on the liabilities side (some prefer ecosystems to appear only on the assets side, for example). In this way, a biophysical debt represents what is owed to the environment as a result of its degradation. This points directly to past degradation and tacitly implies a contrary action. The technical limits for returning below the preservation threshold, as well as political choices, then lead to a selection of what will be preserved and therefore what appears in the debt. So there is no longer a single indisputable debt; it is constructed.

Monetary debt takes conventionalism even further. The switch to the monetary unit introduces more distance with the terms used to qualify environmental degradation. Although this unit allows environmental degradation to be equated with the rest of the organisation's resources, it requires an action scenario to be established. The latter is very often a choice between several possibilities and is linked to a given economic context. Choices about timing or action upstream or downstream, for example, are made according to debatable criteria (cost-effectiveness or social acceptability, strategic action, different technical possibilities depending on the context, etc.). In this case, we are firmly on the side of *constructivist conventionalism*. It is the social investment in the choice of scenarios that will determine the solidity of the monetary debt.

A first element that enables us to limit criticism is to restrict the definition of costs by excluding so-called avoidance costs, which are in fact opportunity costs. While this may remove an important piece of information in the eyes of some, it also means that we are not exposed to the choice of reference scenario for calculating the opportunity cost. For example, if we are talking about avoiding CO₂ emissions by using a train, which reference scenario should we use? The plane, the car? Or perhaps walking, in which case it's no longer a question of avoidance, but of impact. On the contrary, restoration and prevention are not confusing, because the entire expense is for the capital. Of course, there are borderline cases, but it is the role of the accountant or statistician who records real data to make choices about these cases. This is a routine operation for these professions, which are governed by ethical principles and recognised practice (see the chapter on 'Classifying and coding' in Desrosières, 2010).

Finally, the move to the national level represents a further leap forward in the form of a statistical summary of all the ecological debts. The fact that opportunity costs have been excluded means that it is no longer necessary to draw up very difficult meso and macroeconomic transition scenarios. This was a stumbling block considered insurmountable by the SEEA experts of the 1990s (Brouwer et al., 1999; Statistics Netherlands et al., 1997). They considered, quite rightly, that these were major political choices. Thus, our proposal to aggregate corporate ecological debt returns these choices to the individual level. In this way, individuals can count on a better vision of what is possible at their level. Ideally, concertation (planning?) bodies should be set up to ensure that these choices are consistent with higher levels (sectoral, territorial, etc.). The example set by water governance should certainly be followed on this point. Excluding avoidance reduces the interpretation of debt aggregates, which would only include actions that are "marginal" for the transition, but this considerably strengthens their resistance to criticism.

This is where modelling comes into its own. We have used it for artificialisation and water bodies (the case of protected species and habitats is not sufficiently conclusive) (Figure 51). It involves approaching a macroeconomic aggregate by making assumptions and approximations in the absence of very

detailed data at the individual level. These choices made by the observer naturally reduce the resistance of quantification. However, we can see that moving towards an intermediate level that includes real governance and action mechanisms makes it possible to increase the realism of debt. In this way, the work on water bodies is more solid than that on NNLT. This is why we say that water policy is certainly the best place to recognise ecological debts in the medium term.

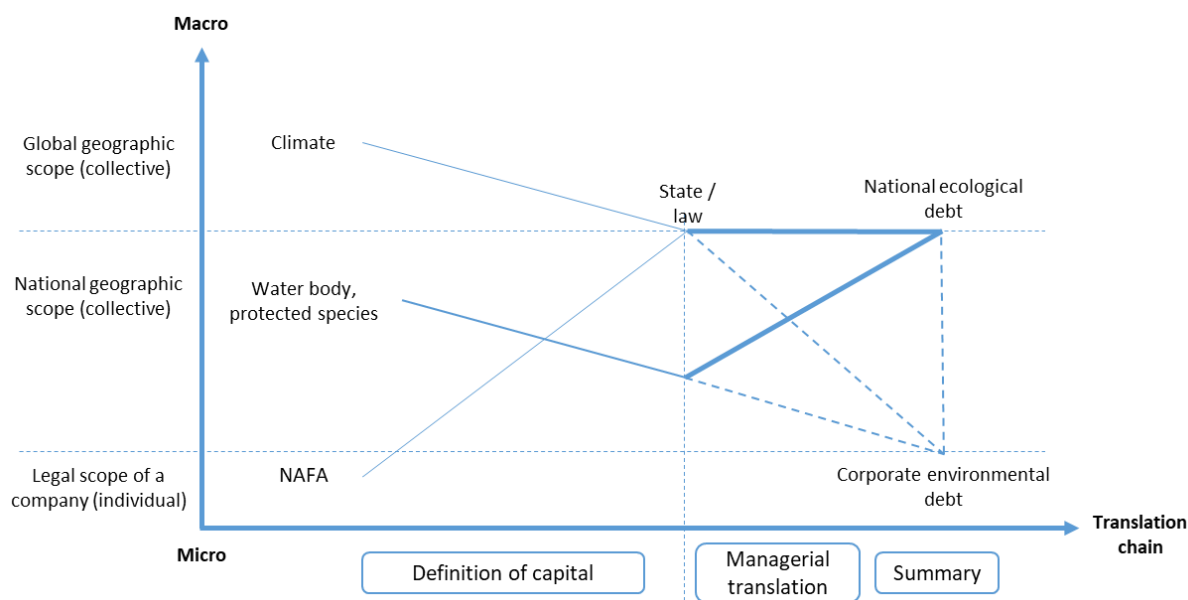


Figure 51 Translation chains including modelling

In this way, ecological debts go from being 'realities' to 'fictions', and then move into the realm of 'useful social constructs' (Desrosières, 2008a, p. 104). Where does the agreement to publish such statistics come from, when they seem to have a more fragile reality? Desrosières points out that everything hinges on their usefulness. The aim of the following section is to illustrate its potential, emphasising that it is based on the micro-macro link.

4. What conventions should be drawn up to reflect the maturity of ecological issues?

To analyse the usefulness of environmental accounting, let us begin by examining its role in the composition cycle of Latour's collective, which we presented in the first chapter.

Let's first clarify the role of the SEEA's ecosystem accounts, before discussing the role of ecological debt.

Ecosystem services (ES), especially when assessed in terms of the future value of the services they could provide, seem ill-suited to commitment, which is characteristic of the last phase of institutionalisation. Or they may be of just one type: the legal owner may commit himself to continuing to produce this service, this value, or to restoring or optimising an ecosystem that does so. But then, no external control can be created. An asset is the property of a given player, and that player is not accountable. In the market logic of payments for Ecosystem services (PES), an external player cannot impose anything, but only buy a service.

We are talking here about the most structured case, where there are actual payments. Whether we like this model or not, we cannot deny it a certain effectiveness. In favourable cases, this type of approach can bring about positive change, at least theoretically. If we can identify contexts where a tangible service can be "produced" by an identified player, and where there is a relatively clear beneficiary, we can build such an exchange relationship. Then the producer, realising that there is potential, will produce an ecosystem.

It is already clear that these restrictive conditions raise questions. Most of the time, it is not even a question of making monetary valuations in the context of payments for ES, but of valuing nature in order to reveal its value in a generic and decontextualised way. In a preparatory document for the revision of the SEEA EEA, the influence of the vision of the TEEB and the World Bank economists involved in the subject in the 2000s could still be seen. The first sentence of the "objective of monetary valuation" section reads: "Ecosystem accounts can be conceived as making the contributions of ecosystem services to economic activity - which in the SNA itself remain mostly hidden - visible." (Barton et al., 2019, p. 10).

The work carried out during this review led to the following recommendation: these monetary valuations must be placed in a broader context of values on the one hand, and of decision-making situations on the other (which is a priori in line with IPBES, 2022; Jacobs et al., 2018, 2016). Thus, biophysical accounts and alternative monetary valuation approaches (through well-being, the modelling of fictitious markets or restoration costs) provide valuable information about these values. In this respect, the authors seem to have taken on board the criticism of the current from which they are partly descended: that which aimed to estimate the 'value' of ecosystems.

They therefore place their monetary approach in a discussion situation that seems appropriate to us if we are in the early stages of the *Nature Policy* cycle. The paragraph of the SEEA EA which lists the possible uses of these evaluations is particularly marked in this sense. Here are most of the examples given (the few others are more heterogeneous, and we quote them below):

" 8.3 Exchange value-based monetary valuations can help to: compare the values of environmental assets (including ecosystems) with other types of assets (e.g. produced assets) as part of broad measures of national wealth; highlight the relevance of non-market ecosystem services (e.g. air filtration); assess the contribution of the environment to improving air and water quality, air filtration); assess the contribution of ecosystem inputs to production in specific industries and their supply chains; compare trade-offs between different Ecosystem services taking into account relative prices; [.. derive complementary aggregates such as national income measures adjusted for degradation; assess trends in income and wealth measures²¹⁸; [...] assess the financial risks associated with the environment". (Committee of Experts on SEEA EEA, 2021)

Taken separately, these (many) examples show that this type of assessment is relevant for understanding the relationship between certain ecosystem functions and economic production processes, which is a contribution to the **perplexity** phase (the first phase). They give a better idea of the importance of services, and therefore of the impact of their loss, if any. In this way, it becomes clearer whether or not the problem needs to be dealt with (Figure 16). At this stage, however, there are two aspects to be questioned: the desire for a routine national warning system, which would consume a lot of resources from the statistical authorities (is this really the best way to mobilise these

²¹⁸ These last two examples provide a very general overview of an emerging problem.

services?); and the fixed nature of the monitoring system, whereas the first phase should in principle be based on versatile measurement tools to incorporate the new and unexpected issues that arise for the community. Feger et al (2017, p.14) issue a very similar warning:

"Ecosystem services monitoring in a context where the level of awareness about ecosystem service degradation is still low and few stakeholders feel concerned is likely to be premature and less impactful than awareness raising and campaigning."

It would therefore appear that the proposed usage model focuses more on the next phase, and that these accounts are probably less relevant for the first phase.

During the **consultation** phase, a more detailed assessment can be carried out, showing who benefits from the services and who is affected by their deterioration. It is therefore possible to mobilise more precise stakeholders (or categories of stakeholders, when we are talking at national level). This seems to be at the heart of the SEEA EA model. Indeed, its whole purpose is to attribute the benefits of services to institutional sectors or branches of activity (which, according to the authors, is quite difficult for many services). A wide range of maps and presentations are provided in the biophysical chapters.

On the other hand, negotiating change already seems more difficult on this basis alone. To do that, we would already need to know who is generating the degradation, in order to know who to hold to account. The SEEA EA assumes that it refuses to define a pressure account, even though this is essential to indicate the responsibility of the players involved. Information on this point can, however, be assembled from different accounts, but we can see that there is no integrated framework for making this analysis. Similarly, information on the actions to be taken to restore the capacity of ecosystems to produce services is hard to find. According to a preliminary note on the consistency of monetary valuation methods for the SEEA EA with the System of national accounts, the costs of restoring ecosystem services cannot be shown because:

"Restoration generally covers several services, and therefore cannot be used to assess individual Ecosystem services." (van de Ven, 2022, p. 24)

It is therefore difficult to see how to evaluate the gains and losses of stakeholders other than the one who suffers the loss of services. What's more, the **prioritisation** stage requires us to compare many different orders of value that cannot be compared a priori (scientific, economic, moral, power relations, types of justification, etc.). On this point, the SEEA's monetary accounts provide information on what is purely a matter of efficiency ("services are provided free of charge at such and such a level") and instrumental aspects. Even so, the SEEA can contribute elements to the scenario by making it more robust through a statistical system developed²¹⁹. But we shall see that our alternative may be richer because it would have the same strength, while reflecting several orders of values.

The last phase, **institutionalisation**, aims to establish routine practices and procedures to ensure that the agreement reached is sustainable. It involves agreeing on how to manage the problem. In this case, it is a matter of monitoring individual commitments to remedy the problem. This is essentially based on the expenditure incurred and the corresponding ecological results. In this context, it is actually possible to better justify actions with monetary service accounts:

²¹⁹ "8.3 [...] provide baseline data to support scenario modelling and wider economic modelling" (Committee of Experts on SEEA EEA, 2021)

"8.3 [...] improve the accountability and transparency of public spending on the environment by recognising expenditure as an investment rather than a cost" (Committee of Experts on SEEA EEA, 2021).

The fact that only one alternative to public spending has been devised to ensure the sustainability of the action raises questions:

"8.3 [...] the application of monetary environmental policy instruments such as environmental markets and environmental taxes and subsidies." (Committee of Experts on SEEA EEA, 2021)

In any case, on the basis of the foregoing, it is clear that relying heavily on the monetary accounts of the BA ES poses difficulties in reaching this phase. However, short-circuiting certain phases in order to impose an order from above runs the risk of being challenged very quickly, leading to the need to redo the entire cycle.

In the light of the developments in this thesis, it is possible to better understand the place of ecological debts (and assets) in Latour's cycle.

We saw in the first chapter that this type of accounting was more closely linked to a phase of **institutionalisation**. In fact, it relies on laws to define the entities to be preserved. This means that these entities have already gone through the composition cycle, and are in principle part of the collective. In reality, the legislative process is limited in scope by the state's actual instruments for action (compliance with regulations, effective incentives, etc.). So the presence of a law does not mean that the cycle is complete throughout the country. The instruments (as defined by Lascoumes and Le Galès, 2004) are precisely designed to ensure compliance with the general agreement reached in democratic bodies (Latour, 2008). As we have seen, the debt accounting approach makes it possible to do this while leaving companies some room for manoeuvre. But it is really a matter of setting up and monitoring routine management by checking the state of capital, the level of pressure on it, the commitments made by those who borrow it, and the level of indebtedness in each sector. In this way, we can determine the imbalance between nature and the economy.

Is debt accounting only useful at this stage? The value of the debt approach is actually broader. It is probably more flexible than the approach of recording "ecosystem assets" and their potential value. In fact, it does not seek to totalise a priori the whole of the living world by assigning it a value, which may be subject to revision, but which is displayed for all to see as the one that should be used. On the contrary, it is based on the ecological entities that are actually used and of concern. In this way, certain parts of nature are left aside until both conditions are met.

But this does not prevent us from linking the accounting of ecological entities that have already been taken on with those that are in call or at the beginning of a cycle. Let's imagine that we already have an accounting system incorporating the capitals mentioned in the previous chapters (linked to the Nature, Water Framework Directive and Marine Environment Directives, for example), and that pollinators, which are the subject of increasing attention, (r)enter the cycle because of their decline. At the **perplexity stage**, we would be wondering what services they provide, how dependent they are on the economy, but also what their status is, which species are more or less close to extinction (within scientific limits), and so on. The framework provided by biophysical debt, i.e. systematically comparing status with a preservation threshold and taking an interest in all ecological entities (not just those that are 'useful'), is a real value added compared with the Ecosystem services framework alone. This is more

or less what is made possible by the biophysical state accounts of the SEEA EA (see Chapter 4). The next phase, **consultation**, can also use this approach in the same way.

During the **prioritisation** phase, it is not directly the National accounting already established that could be used, but all these principles can be used to develop models that scenario the inclusion of this ecological problem. The debt concepts and frameworks can be used directly: biophysical state, sensitivity analysis for different possible thresholds, scenarios for several types of action (avoidance, reduction, restoration) depending on the sector, etc. How will the newcomer consume resources that could have gone to other debts (including financial debts)? Or, on the contrary, can repayments be pooled? Linking up with the existing collective helps to stabilise the position of new debts.

Thus, while it appears that the SEEA is very well suited to the consultation phase, but much less so to other phases, the debt approach is, on the contrary, very closely linked to the institutionalisation and maintenance of a collective. The risk with the SEEA EA is that ecosystems become fixed assets in a permanent consultation phase, because the accounting system is standardised and very detailed. Moreover, involving this statistical tool in such a phase may seem contradictory. National accounting, as a heavy statistical tool and as standardised (and therefore relatively stable) balance sheet accounting, seems much more clearly linked to the last phase of the cycle. Ecological debt therefore seems better suited to the traditional role of National accounting, which takes existing categories and builds on them.

5. Ecological debt at the service of ecological transition

To understand the usefulness of ecological debt, we need to place it in a slightly broader context. Discussions on the limits of GDP and the alternatives to be proposed have led economists to give their opinion on the direction the discussions are taking. Thus, Pottier (2018) and Timbeau (2022) converge on the idea that accounting does indeed have a certain performativity of its own, but that it has its limits.

In the field of accounting and the sociology of quantification, it is often said that accounting is performative (Espeland and Stevens, 2008; Feger, 2016; Richard, 2015). This idea, which originally came from the analysis of language, means that mere enunciation realises an object. This covers two different ideas which have in common that they are direct consequences of the simple formulation of the accounting figure in a particular context. The first is that indicators and accounts "direct attention, persuading and creating new categories for understanding the world". (Espeland and Stevens, 2008, p. 404). The second goes further, saying that in certain contexts, enunciation generates action on the part of the interlocutor (ib.). In the case of accounting, announcing a performance leads to a sharing of profits or, on the contrary, to liquidation. Announcing a GDP value has major political effects if a government has committed itself to growth rates, etc. (ib.).

Here, accounting has a function of coordinating the stakeholders around the figure and a function of transparency that allows for non-conflictual exchanges. Accounting is thus seen as a cornerstone of the capitalist economy (Timbeau, 2022 quotes Biondi, Aglietta and Cartelier). However, Pottier (2018) and Timbeau (2022) also point out that other elements shape economic and political life. Companies are at the heart of a network of constraints, rules, incentives and intrinsic motivations that guide their actions. The quest for profit is the main one for many, which can then be expressed in a number of ways: maintaining a stable position in a market segment, growth, etc. This is also the case for politicians, who seek above all to be re-elected by representing the aspirations of the public.

In the rest of the discussion, we shall try to clarify two aspects in turn: firstly, motivations, by asking ourselves what role accounting can play in changing them. Secondly, we will look at how accounting can form part of a system of decision-making and action in which the state and companies work together around new, more ecological rules and incentives.

Table 50 summarises the rest of the discussion. It describes the links between a selection of accounting conventions that are particularly important in our view (described in the central column) and their connections to various key dimensions for action: the way in which companies would naturally deal with ecological debt or ecosystem assets; the link with state instruments; the actors potentially favoured by these conventions; the link with the expected ecological outcome.

For the sake of simplicity, we have not added the ecological assets component of our approach. However, it should be borne in mind that the left-hand side of the table can be modulated slightly to show this instead of the SEEA EA approach.

5.1. Accounting to bring new motivation to the heart of the company

To deal with corporate motivation, we feel it is important to remember something that may seem obvious, but which is rarely explicitly detailed in economics (in particular): a company is made up of individuals. Therefore, analysing the "motivations" of a company is based on those of the human beings that make it up. Of course, there are some relatively stable motivations that have settled in people's minds so that the company can continue to exist: maintaining a certain cohesion and efficiency, focusing on sales, and so on. But if we want to bring in new motivations, we need to do so by relying on the people who carry them out and analysing their place in the company. These players, who can be described as environmental, are present today, but we can see that the issues they defend cannot be expressed in the terms of the most stable language at the heart of the business model, accounting. It is therefore impossible to really confront and justify motivations other than profit.

To approach this question of motivation, we can try to bring it closer to the theory of justification by Boltanski and Thévenot (2008) extended by Mermet (2007; Mermet and Leménager, 2015) to add an ecological city. In the current accounting framework, what is written above means that the ecological city does not have a voice in the company, at least with the vocabulary that structures it. Integrating this register of justification, which values the state of nature and respect for ecological limits, would make it possible to compare these registers of values and, above all, to explain, a posteriori, the compromises made. If an additional cost is linked to the environment, it would be possible to explain it in accounting terms, in a transparent and standardised way. Stakeholders such as customers or investors (who are also sensitive to this register, because they have this ecological motivation) could make decisions on this basis. This is of course aimed at external players who themselves have an environmental motivation, such as green investment funds or customers who are sensitive to this dimension. But we can see the potential for connection and transparency that this would allow. The same applies at national level.

Do all the accounting conventions allow this exercise to be carried out? How does the method of accounting integration influence the possible discussions and thus the comparisons between cities?

Ecological debt is much more closely linked to the world of regulation than it is to the world of assets. This aspect can be compared with Boltanski and Thévenot's civic and commercial city. The contracts

that govern borrowing come from the law. Debt is also based on the market dimension, since there is a mutual interest in the exchange. By relying on ecological debts to manage ecosystems, the common good would be achieved through compliance with legal procedures and rules that lower ecological limits, which have become regulatory, to the level of the company. Depending on the ecological entities in question (climate, ecosystems, species, bodies of water, etc.), and the technical means (restoration, reduction), a greater or lesser margin of borrowing, of credit, is allowed. At the same time, we can see that this space is not reduced to a single value that everyone should follow. The advantage of debt is precisely that it leaves room for freedom around the limit, a margin for manoeuvre that allows the company to borrow if it really needs to. This allows civil and commercial compromises to be made.

The additional recording of ecological assets enables another register to be materialised and discussed on a quantified basis and connected to that of legal liabilities. In historical cost accounting, the field of assets is clearly located in the industrial city. Companies are looking for efficiency in their choice of investment, and then in the 'use' of these assets. What assets should I acquire to optimise my business model? To open up a new market segment by leveraging existing assets? How can I make the most of each asset? And so on. So we can see that an ecological-industrial compromise also applies very well to ecological assets: given that a debt has to be repaid eventually, the company has to choose carefully the impacts it is going to make on the environment according to what it expects from it. Is such an impact really essential or unavoidable? Wouldn't it be better to review part of my business model? Or should I modulate my impacts so as not to reach an irreversible threshold that would make me insolvent?

Remember that debts and ecological assets are physically linked: a degrading use, i.e. an asset, relates to a given capital, unlike liabilities and financial assets which are entirely fungible and separable. In this way, the two parts of the balance sheet and the registers used to justify the corresponding choices are inseparable. It is therefore the simultaneous creation of two interconnected accounting components for ecological entities that allows ecological limits to be placed at the heart of the company's business model. All of this makes it possible to bring these limits into the two traditional modes of accounting justification.

We can see the extent to which the accounting structure and the way in which ecological entities are recorded are performative. They frame discussions about the ecological object in a very specific way. In this case, in the sense of reducing degradation. But there are other approaches, based exclusively on Ecosystem services or the integration of ecosystems as assets.

For Mermet and LeméLeménager (2015, p. 211):

"The notion of Ecosystem services is clearly rooted in the industrial city, founded on the concern to produce services in the most rational way, by properly managing ecosystems, considered here as natural facilities for producing services. The foundation of EESEs is therefore an industrial-market compromise".²²⁰

The monetary accounts of the SEEA ecosystems are undoubtedly in this vein. (Committee of Experts on SEEA EEA, 2021, pt. 6.1 & 8.1). We can see the advantage of adding the additional aspect of ecological debt: it adds another order to this compromise, that of the civic city.

²²⁰ They also add that "Various proposals aim to broaden this compromise, for example by carrying out evaluations in a participatory way, to add a civic legitimacy to them".

Our proposal does this by sacrificing three elements of the SEEA: complete coverage of Ecosystem services as listed today; an estimate of the value of future services; and recording of ES in all situations, whereas we only do this in the case of use that leads to degradation (on the asset side) or if society really recognises them as a conservation concern (on the liability side). Let's clarify this last point. Firstly, such a concern for preservation would be instrumental and anthropocentric, but it remains a perfectly valid motivation. In addition, we can cite at least two situations where such concerns are well identified: when the ES are particularly tangible and are the subject of a market (but in this case, the passage through the ecological debt is not necessarily very useful, since market mechanisms should in principle be sufficient to produce these ES); the Strategic Framework Directive for the Marine Environment contains two descriptors linked to supply ES (3, on commercial species) and regulation ES (9, on contaminants affecting seafood). Thus, there remains a significant place for ES, while opening up much more widely the types of values and justification registers included in our accounting of ecological debts²²¹. Thus, whereas approaches such as the SEEA are based solely on an industrial-market compromise to introduce ecosystems into accounting, our approach makes it possible to add not only a civic aspect, but also a real ecological dimension.

²²¹ In any case, there are areas of non-recovery between our approach and that of the SEEA EA, and it should be possible to devise an accounting structure that integrates the two.

General discussion										
Reading					Reading					
Link ecological result to	Link with governance	Connection to government instruments	Self-management by the company	SEEA	Type of agreement	Ecological debt	Self-management by the company	Connection to government instruments	Link with governance	Link with ecological result
Appropriation of new value carriers (potential impact)	No changes to governance	<ul style="list-style-type: none"> Incentives through distortion of asset prices (tax incentives) No regulations 	<ul style="list-style-type: none"> Optimising investments to maximise the value created (investment selection techniques) Amortisation obligation 	<u>Assets only</u>	The role of the environment in the accounting structure	<u>Liabilities (and assets)</u>	<ul style="list-style-type: none"> Repayment obligation Optimising the cost of capital 	<ul style="list-style-type: none"> Law (polluter pays, prudential rules) Taxation (by debt ratio; by type of employment) Target achievement / planning / accountability 	Possible inclusion of capital representatives	Use of the environment negotiated with stakeholders, in particular capital representatives
Good resource management (but risk of optimising ecosystems to produce a service)		Payment for Ecosystem services	<ol style="list-style-type: none"> Research into new securities Optimising the value drawn Nature-based solution as a substitute for other assets/optimisation of an ES package 	<u>Ecosystem services (capacity account)</u>	Main type Three questions: <ol style="list-style-type: none"> Inclusion / exclusion Unit management Relationships between units 	<u>List of entities to be preserved (report account)</u>	<ol style="list-style-type: none"> Reasoned choice of whether or not to use capital Optimising the level of employment (because we know we'll have to pay it back) Hierarchy of debts to be settled 	Definition of new entities to be managed collectively		Preservation of ecological entities of concern
Help in choosing investments to optimise returns	Of interest to investors	No	Increasing or optimising trade-offs	<u>Net present value</u>	Quantification method	<u>Preservation costs</u>	Reduce the cost or optimise it in line with the expected gains from employment	<ul style="list-style-type: none"> Allocation of budgets/ecological quotas Subsidies to help pay off debt 	Of interest to env.	Estimating the cost involves preparing the preservation action.

Table 50 Comparison of ecological debt and SEEA action models

5.2. The State, the market and environmental statistics

The second issue raised by Pottier and Timbeau is that of incentives. Here the state has a major role to play: new rules and standards, price distortions through taxation, fiscal policy that can steer production, shareholdings to steer the decisions of key companies, etc. We propose to approach this question by taking up Desrosières' table, described in the first chapter. We propose to approach this question by taking up the Desrosières table, described in the first chapter.

Our journey through environmental accounting has brought us across many approaches that can be likened to the five forms of state defined by Desrosières. For example, stock-flow accounting frameworks are similar to an engineer-state vision, seeking to optimise their use. The SEEA EA, because it proposes to reveal the value of all ecosystems, is similar to a liberal version of the State, which would only provide statistics offering a general view of the risks and opportunities in the business environment. A neo-liberal version would not see the emergence of new national environmental statistics, but only extra-financial *reporting* approaches. There are several possible versions of this. A restricted and pure version, which would only ask for information useful to the financial markets, i.e. on the risks and opportunities linked to the environment, as proposed by the ISSB.

The place of ecological debt within this framework has yet to be defined, but various possibilities are already emerging. Is it a tool that blends in with statistics or accounting in general, adding only a slight colouring to these categories? Or is it simply a variation on a particular type? Or do we need to create a new type of State that is both adapted to the scale of the challenges and incorporates a debt approach?

The first approach makes sense, because this global framework based on ecological debt has its origins in accounting thinking and can be linked to the economics of conventions. A new accounting convention is not a radically different information framework. What's more, its flexibility and scope make it easy for different economic schools to grasp. Once the transitional period of adoption is over, a liberal economist or government may see ecological debts as a price signal that finally incorporates environmental externalities. A Keynesian economist will try to control the macroeconomic ecological debt to keep its volume within acceptable limits by activating the levers of subsidies or tax incentives. A more interventionist state could introduce prudential rules based on ecological solvency or take stakes in companies whose ecological debt is too high. In this way, we find the whole range of state interventions reinforced by the introduction of ecological accounting.

This suggests that state action cannot be radically reinvented. But history shows that it is precisely in the re-use of certain elements to which innovations have been added that other forms of State have emerged in the past. So let's look again at the model of action that is envisaged for the State with the articulation of national and corporate ecological debts to see whether a new State might not emerge.

5.3. Green state, limit state or green neo-liberal state?

The first step towards finding a new type of state is to take note of the changes in the economic context over the last few decades. As Pottier (2018) the conditions for the success of French-style planning have disappeared. The plan only worked because the State was well equipped at the end of the Second World War: "State supervision of bank credit, limited trade with the outside world (as a consequence of the refocusing of economies after the two world wars), changes in income negotiated between social partners, coordination between the State and large companies, macro-economic closure through public spending by the State" (Pottier, 2018, p.153). These instruments no longer exist, and

neither do the economic conditions that enabled them to be effective: relatively closed economies, the weight of industry, the absence of major economic players able to counterbalance the power of the state, globalisation, etc. All Western economies have had to adapt to these conditions. All Western economies have had to adapt to these changes, which were no longer completely under their control when they took place.

In a neo-liberal economy where the principle of subsidiarity (leaving as much freedom as possible to lower levels and allocating powers to the appropriate levels) and procedural action (which consists of laying down decision-making and negotiation procedures) are paramount in varied and complex networks, the State cannot be the centre of all action (Desrosières, 2008a, p. 111). Today, the State is decentralised and has left a great deal of power in the hands of agencies with which it has contracts of objectives; to the regions, départements and metropolises, to name but a few, to which it has left its own 'competences'; to supranational institutions; and to businesses, which operate in a space framed by standards rather than by strong intervention.

That said, when individual economic players are motivated by factors that may be harmful to the environment, or by market failures, neoclassical theory dictates that the state has a role to play. What's more, beyond the field of managing economic externalities, the political collective retains its right to oversee the life of the city and can change the rules of the game to preserve "matters of concern". (Latour, 2008)matters of concern.

In this way, the state can help to define the relationships between the nodes of the economic network (organisations, companies, individuals, etc.), using normative instruments that are more flexible than regulations (Halpern et al., 2014; Lascoumes and Le Galès, 2004). These aim to adjust the life of civil and economic society. They have a mixed legitimacy. On the one hand, they are scientific-technical and democratically negotiated. On the other, they are based on market mechanisms and offer a framework of freedom.

In particular, these standards enable the State to highlight responsibilities. The accounting programme proposed here is perfectly in line with this: accounting is based on standards, and the State uses them to co-define the ontology of the capital that is the object of preservation concerns. In this way, the choices of how to represent the environment, in the form of indicators and individuals or organisations, because they are partly political, fall to the State, in collaboration with scientists who have detailed knowledge of these 'natural' objects. This stage can be likened to the definition of a negotiating framework, which prepares the ground for future discussions (Zartman et al., 1982). The question of maintenance thresholds is also co-constructed. These are closer to the idea of "policy", as they are more clearly part of a bargaining logic (Raiffa, 2003).

This is followed by a pre-action phase, which involves calculating the budgets needed to meet these thresholds if they have been or will be exceeded. We prepare for possible action, estimating more precisely the efforts that may be required. In short, we pre-organise. The publication of the information produced can still lead to effective reorganisation if the motivations of organisations and individuals were pre-existing, if the only barrier was the lack of information.

In a second stage, the State can intervene again, through National accounting. Once the information has been framed and accountability organised, the State can construct a total vision (the National accounting of debts) for the purposes of new actions to promote the achievement of environmental objectives set at macro level. In addition to the normative framework that has been defined, it can guide behaviour by providing incentives through taxes, subsidies, permit markets, or by imposing stricter regulations (solvency rates or prudential rules, for example). All these instruments then find a

robust foundation at the individual level thanks to the new Business accounting standards. The first stage of the work will be to restructure these debts by agreeing to use ecological thresholds that are not fixed, but follow trajectories towards the 2050 neutrality objectives that have already been defined.

Does this mean that this approach is a hybrid of a neo-liberal state with national steering to get back within ecological limits and stay there? This is an open question.

Epilogue

Thinking the "ecological debt" of our national economy as a basis for truly ambitious ecological planning

Clément Surun, Morgane Gonon, Ecological Accounting Chair, CIRED, unpublished text, 03/08/2022

The expression "ecological planning" has been used in two presidential campaign programmes and by the Shift Project in its Plan de Transformation de l'Économie Française (PTEF) (The Shift project, 2022). At the beginning of May, France Stratégie - the successor to the former Commissariat général au Plan - published a report imagining "renewed planning" to "align different areas of public policy in relation to sustainability". (Barasz et al., 2022) an issue that is now at the heart of the debates surrounding the legislative elections and the new government's outlook.

It is hard to imagine today what an economy channelled by a "plan" and aimed at achieving objectives of general interest might look like. The post-war economic and social context that associated planning and reconstruction plans is no longer the case: in our polycentric, open economies, the State is one player among many, interacting more than it imposes; public control of a country's macroeconomic destiny is largely a fantasy. The recent use of the term "planning" in the media and in political discourse is a reminder of the imaginary power and capacity of the State, which can only remain a pious hope if it meets at least three conditions:

- the creation of a tool for monitoring and adjusting government action on the environment and the economy. Within the Ecological Accounting Chair, we propose to define and calculate ecological debts integrated into National accounting, which is the subject of this contribution;
- legitimate governance accountable for achieving ecological objectives;
- an assertive renewal of the State's role in the economy.

The multiple use of the term "planning" leaves some doubt: are we talking about planning public action or planning the economy as a whole? Reducing planning to a *retro-planning* of government action alone will necessarily miss the objective of coordinating the players involved, which is essential to a genuine ecological transition of societies. Even if it is essential to define a vision and bring public policies into line with each other (water policy and agricultural policy, for example), it is above all a question of reorganising State-society interactions to overcome clearly identified obstacles: fragmentation of responsibilities²²², lack of visibility and anticipation of future environmental standards, virtual absence of budgeting for the efforts to be made to reduce our greenhouse gas (GHG) emissions or preserve our ecosystems²²³. Genuine planning would make it possible to calibrate the State's incentives and support measures to achieve a rapid ecological transition, leaving no one behind.

Going beyond the usual questioning of the merits of GDP to find real operational solutions

It has been widely repeated since the 1970s that GDP is unsatisfactory for guiding public action or serving as a tool for international comparison. The recent France Stratégie report highlights its

²²² See for example: (Edelenbos and Teisman, 2011).

²²³ In France, the work of the [Institut de l'Économie pour le Climat \(I4CE\)](#), or the Institut Rousseau et al (2022) (which are not General Governments) provide estimates of financing requirements for the climate, but biodiversity is not currently the subject of similar analyses.

limitations: disconnection from well-being or happiness, invisibility of environmental degradation, very limited description of non-market and domestic activities, inequalities that are poorly addressed.

There is no shortage of alternatives to GDP: Nordhaus and Tobin's Economic Well-Being (1972), the Human Development Index (1990), the *Inclusive Wealth Index* (2012), the Ecological Footprint (Wackernagel et al., 1999) and the Sustainable Development Goals. In France, the Stiglitz-Sen-Fitoussi commission (Stiglitz et al., 2009b) and the simultaneous launch of the Forum for Alternative Indicators of Wealth (FAIR) (Gadrey and Jany-Catrice, 2016) have led to the creation of around ten New Wealth Indicators²²⁴. However, beyond the media hype, these 'new indicators' are rarely used for operational purposes: indicators that are too aggregated for some, questionable legitimacy for others, disconnection from decision-making processes, and above all, for all, lack of integration with economic data, the heart of public policy, are all likely reasons for their low use. Today, they seem condemned to counting the destruction of the environment rather than helping to steer a transformation of the economy towards sustainability.

The ecological question calls for the updating of the statistical and accounting tools that have historically served the development of the modern State, as a political entity capable of governing a national space (Desrosières, 2010; Fourquet, 1980; Miller, 1986). If we do not limit the issue of transforming national accounting to the old refrain of a GDP corrected by environmental degradation - a solution rejected by both experts and politicians - then the national accounting tables can provide an integrated representation of the interactions between economic performance (growth, financial stability, unemployment, etc.) and ecological performance (state of biodiversity and GHG emissions).

The "ecological debt" as the basis for a truly ambitious and costed environmental policy

Calculating real *ecological debts*²²⁵, i.e. what economic players, and more broadly sectors and the economy as a whole, borrow from the environment to carry out their activities (by degrading ecosystems, polluting the atmosphere with GHGs, overexploiting natural resources, etc.), is a credible alternative and a potential source of major change. These debts can only be biophysical (hectares to be restored, tonnes of pollutants to be purified from water, etc.), as nature has no use for euros. They can only be contracted if there are actions to reduce and restore the environment. Otherwise, degradation must be prohibited or accepted as irreversible.

To get to the heart of the economic decision, biophysical borrowing can be translated into monetary terms by calculating the sum of the expenditure required to prevent or repair the impact on the environment and thus respect a carbon budget or good ecological status. Ecological debt and its corollary, ecological solvency, would make it possible to open up discussions based on the same language to debate the trade-offs between growth and the environment, public and private budgets and planetary limits, or even sustainable debt levels. Presented within the framework of National accounting, ecological debts can appear at the same level as public or private debts, as a temporary resource from which economic activity benefits, and which requires a partial redirection of income from economic activity (from GDP) to balance them out, where possible. An ecologically "sustainable"

²²⁴ Published on the INSEE website.

²²⁵ The concept of national and then disaggregated ecological debt has been explored in greater depth in the work of André Vanoli, INSEE's Director of National accounting, statistical coordination and international relations.

economy is one that avoids pressure on the biosphere as much as possible, and thus incurs as little debt as possible.

Linking macro- and microeconomic ecological debt, a key to planning

Rethinking state intervention through planning obviously cannot be done at national level alone. The prism of ecological debt opens up new perspectives for ensuring coherence between national, sectoral and territorial levels. Water governance in France offers an example of multi-level coordination that can serve as a source of inspiration: the translation of European objectives to national levels, from the hydrographic basin down to the river, is discussed by local bodies that bring together stakeholders who use or have an impact on water bodies, as well as public representatives.

Accounting for ecological debts at these different levels, as a common and lasting representation and language, would make it possible to ratify reciprocal commitments, between players acting at the same level, and between levels. For example: application for national subsidies by a regional player or by a representative of an economic sector to redistribute them, subject to conditions, to individual players.

Built on the idea of ecological debt, ecosystem-centric accounting (Feger and Mermet, 2017) or the CARE business accounting model (Rambaud and Chenet, 2020; Rambaud and Richard, 2015) could equip the meso and micro levels and be linked with - and feed into - a national vision of the actions, possibilities and needs of each individual. On the basis of this harmonised and integrated data, it would be possible to think in terms of enhanced public intervention: tax incentives, regulations, financial aid, equity investment, contractual approach, land-use planning guidelines, etc. Accounting based on the ecological debt of stakeholders paves the way for the coherence of environmental policies and the more precise targeting of actions.

This method requires the production of robust data at the level of the players, in a systematic and routinised way, within the framework of real ecological *reporting* requirements. Just as in France today, accounting and tax data are used to monitor macroeconomic performance, environmental reporting and integrated accounting are essential to robust, consistent and operational national ecological accounting.

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Appendix A. Links with other economic disciplines

This appendix is based on the description of economic trends by a group of authors (Aboobaker et al., 2016; Boerger and Exploring Economics team, 2016; Dimmelmeier and Heussner, 2018). Some issues are of course cross-cutting (such as the analysis of economic behaviour or the allocation of scarce resources), but these authors sometimes link them more or less strongly to certain currents.

It is rather with **institutionalist economics** that there are bridges with this thesis. Although implicit (we have not used any frameworks or authors from this current), our work can easily be linked to it. Indeed, accounting (National accounting or Business accounting) corresponds to the definition of institutions: "the regular and structured behaviour of people in a society and (...) the ideas and values associated with these regularities" (Neale, 1994). Our work is also based on an epistemology and methods found in this discipline (Dimmelmeier and Heussner, 2018). It first aims to understand accounting as a situated institution with effects on behaviour. In particular, we describe accounting conventions from a historical point of view, and sometimes classify them, in order to draw out information that seems relevant to us: relationship with an institutional context, effects, and so on. Our aim is not so much to construct an explanatory edifice for this or that economic situation which is linked to a particular form of accounting, but rather to prepare, with full knowledge of the facts, more or less significant adaptations of these accounting conventions in order to adapt them to our own context. We are therefore taking a rather constructivist approach, in the knowledge that accounting, as a 'representation', cannot deviate too far from what it seeks to observe, otherwise it will fail in its objective. On the other hand, as a model, as a simplification, it is sometimes obliged to make contingent choices, which help to give a different existence to what it quantifies (Desrosières, 2008a).

Another aspect that can be linked to institutional economics is our discussion of public policies on water and biodiversity from an accounting perspective and the attempt to link the two. The aim is to build and bring together institutions that are currently relatively separate.

This work is not explicitly based on **(post)Keynesian** economics, which is a missed opportunity. If this thesis wanted to follow the history of NA, it would have been necessary to prepare and adjust the definitions of the accounts according to the interpretative frameworks, the objects studied and the main questions of this discipline. To put it simply, we invite authors who identify with this current to take up the new macroeconomic aggregates that we will propose and discuss them with a view to including them in their models. Bezemer (2016) suggested an "accounting vision" of banking, money and macroeconomics. We hope to contribute to his wish as far as the environment is concerned.

It should be noted that our methodological positioning remains quite different from (post)Keynesianism (Aboobaker et al., 2016). We do not seek to explain economic phenomena or to tell stories that are as plausible as possible by mobilising modelling tools or the identification of stylised facts that constitute relatively stable patterns.

On the other hand, our conceptions of the capitalist economy are extremely similar: the monetary economies of production seem to us to be effectively based on a financial system of credits which serve to invest and pay for the various items of consumption, before leading to production whose purpose is to repay the initial loans. The role of the financial system is therefore central, as is the analysis of the interactions between actors and between the accounts that each one keeps. In this way, the accounting model we propose fits in perfectly with the coherent stock-flow models or multi-agent models used by post-Keynesians.

The links with the neoclassical school seem to be much weaker, and we make proposals that may seem to compete with it (genuine savings, for example). To mention just a few points to which we will return, the absence of stock-based reasoning and the almost exclusive focus on profit seem problematic to us, particularly when it comes to dealing with sustainability issues. (Boerger and Exploring Economics team, 2016). The question of *allocating* scarce resources is not at the heart of our work. From a normative point of view, this thesis does not aim to answer the question "what is the optimal decision?", but rather "what is the most useful information for making decisions in a given context?". Consequently, the question of the rationality of actors is not an issue. From an epistemological point of view, methodological individualism poses a problem for the very existence of the state and regulation, and is opposed to the foundations of biology, which we are mobilising. Our perspective is clearly more emergentist, even holistic (Bergandi and Blandin, 1998). As we have seen, in relation to the neoclassical school, we take a much more nuanced realist stance, while universal and anhistorical explanations and propositions do not seem possible to us in general.

Appendix B. Clarifying the differences between accounting and economics

Figure 52 shows the relationship between economics and accounting. Note that Aukrust's attempt to base National accounting on microeconomic principles (Vanoli, 2002) was not followed up.

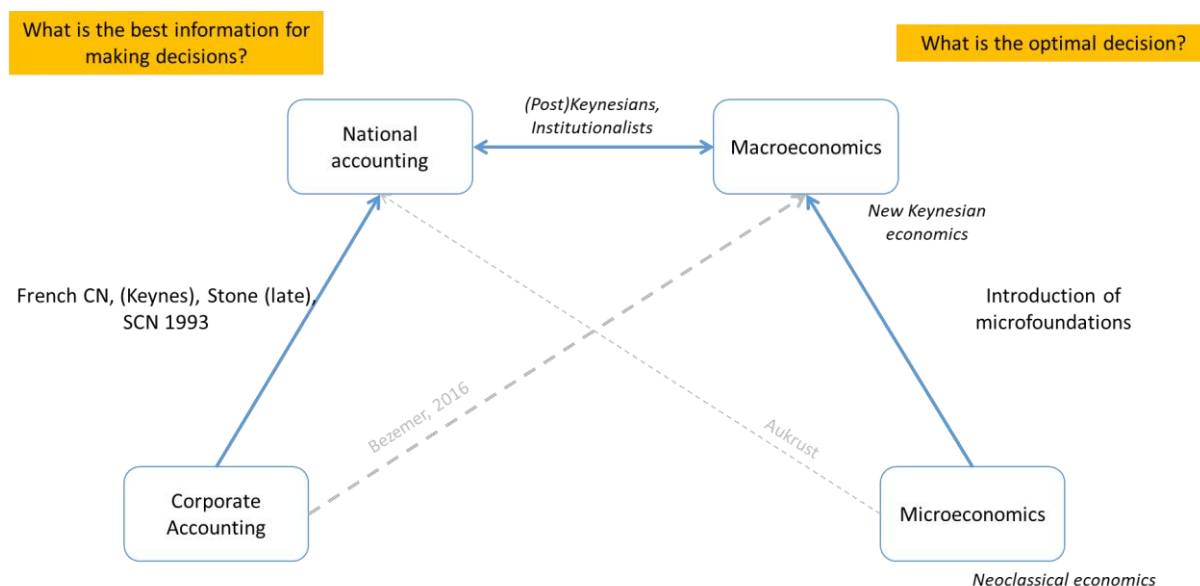


Figure 52 Possible diagram of the relationship between economics and accounting

Legend: the thickness of the arrows represents the strength of the connection. Solid arrows correspond to actual exchanges, while dotted arrows represent programmatic reflections. NA: national accounting; SNA: System of national accounts. New Keynesian economics, which can be represented by Stiglitz, Akerlof, Romer, Samuelson, Krugman and Hicks, is a synthesis of historical Keynesianism and neoclassicism.

There are a number of differences between national accounting and macroeconomics, resulting in different representations (Table 51).

Table 51 Comparison between National accounting and macroeconomics

	National accounting	Macroeconomics
Level of reality	Observation	Modelling
Relationship to time	Static	Dynamic
Objective	Description of the (present &) past	Explanation and prevision
Cognitive status	Institution	Thinking exercise
Sources	Administrative data, corporate accounting, surveys	NA and ad hoc databases

National accounting and macroeconomic models are both representations of the national economy. But whereas the former is a descriptive model, the latter is an explanatory or predictive model. As a result, there are a number of differences: one is based, at most, on the observation of economic facts, while the other allows itself a number of assumptions, sometimes strong ones. The NA is necessarily static and photographic, whereas there are a variety of dynamic models in macroeconomics. Finally, their use and status are different: the NA, by virtue of its stability and the organisational uses made of it, is a formal institution. On the other hand, models are often the work of researchers or institutes

that regularly rework them in response to specific questions. This point can be qualified insofar as certain 'large' models are perennial (models of the General Directorate of the Treasury, etc.) and relatively stable. On the other hand, even if they do trigger action, they lack the transparency and standardisation required to reach the level of institutionalisation of the National accounting system.

Appendix C. Chronology of the PCG and the NA

Table 52 Comparative chronology of the French PCG and the development of National accounting

Date	Plan comptable général (French GAAP)	National accounting	General context
Suites 1929			3 ways: <ul style="list-style-type: none"> - Dictatorship and militarisation (Germany, Italy, Western Europe) - Planned economy (USSR) - State intervention and demand-led macro-regulation
2 ^e GM		1 ^{ers} National accounts under Keynes's impetus	
1943	Drafting of a monistic plan based on the principles of circuits and permanent inventories and very much inspired by Reich's plan, itself inspired by Schmalenbach's plan. Never implemented due to the turn of the war and the reluctance of employers.		
Post-war			The idea of state intervention took root. The intervention mechanisms inherited from the war were adapted (control of foreign trade, prices, wages, exchange rates and credit persisted). Strong idea: society must seek to define and control a collective destiny by taking advantage of the market and individual initiatives, but without relying entirely on them.
1946		FR: Creation of the Commissariat général au Plan (economic guidance through qualitative plans, including consultation)	
1947	Publication of a first version of a two-tier plan		
1957	Minor revision		
1950		France: creation of the SEEF at the DG Treasury	
1968		SNA 68	

1970		SEC 70	
Mid 70's	Reform of PCG 57 (launched in 1971)	Predominance of TC, economic and social policies of structural transformation, disappearance of growth policies.	Crisis in macroeconomic regulation (following the opening up and liberalisation of economies, criticism of the negative effects of growth, and the failure of the countries of the South to develop and control their imbalances. Individualism and the increasing complexity of economies also play a role. The oil crises accentuated the problem, leading to unemployment and a loss of economic momentum. Neoclassical theories came to the fore, as did neo-liberal incentive policies based on micro-behaviour. p.558 (Vanoli, 2002)
1982	Restructuring of expense accounts by nature, enabling the macro indicator of Value added and Earnings before interest, taxes, depreciation and amortisation to be calculated.		
1995		SNA 93 / SEC 95	
1999	Minor revision		
2008		SNA 2008	
2022		Launch of the 2008 SNA review	

Appendix D. Use of tax returns by national accountants

La déclaration de bénéfices faite dans le cadre du régime de l'IS

La déclaration reproduite ici est celle qui est faite dans le cadre du régime d'imposition à l'IS.

Il s'agit de la déclaration qui contient le plus d'information comptable. Elle comporte les données suivantes :

1. Un ensemble permettant d'identifier l'entreprise, et comportant des informations de nature fiscale.
2. Un bilan.
3. Un compte de résultat.
4. Le tableau des immobilisations.
5. Un tableau relatif aux réévaluations.
6. Le tableau des amortissements.
7. Le tableau des provisions.
8. Un état des créances et des dettes.
9. Un tableau de détermination du résultat fiscal.
10. Un état des déficits.
11. Un tableau d'affectation du résultat.
- 12 à 15. Des informations sur les plus et moins-values.
16. Un tableau de détermination de la valeur ajoutée.
17. La composition du capital social.
18. La liste des filiales et participations.

Les informations utilisées pour les besoins des comptes nationaux dans le cadre du calcul du PIB portent uniquement sur les informations figurant dans les fiches 2, 3, 4, et accessoirement 6 et 12 (calcul de la FBCF).

Figure 53 Content of the tax return and its use by National accounting (source: Magniez, 2009, p. S-36)

Appendix E. Comparison of BA and NA operating accounts

Figure 10-1 The operating account in business account (and in tax returns)

Business accounts			National accounts	
Operating income	Turnover		Output	P.1
	Production taken into inventories			
	Capitalised production			
	Miscellaneous income		Subsidies on products	D.31
	Balancing subsidies			
	Reversal of amortisation and provisions			
Operating expenses	Purchases consumed		Intermediate consumption	P.2
	External charges		Taxes on production	D.2
	Taxes		Compensation of employee	D.1
	Personnel expenses			
	Depreciation, amortisation			
		Operating profit	Gross Operating Surplus	B.2g
Financial income	Financial income			
	Reversal of amortisation and provisions			
Financial costs	Financial costs			
	Depreciation, amortisation, provision			
		Financial profit		
Exceptional income				
Exceptional expenses				
		Exceptional profit		
Equity financing				
Taxes on earnings				
		Excess of income over expenses, net income, net profit, net earnings		

Figure 54 Comparison of BA and NA operating accounts (source: Hauseux 2020, p.390)

Appendix F. List of meetings of the SEEA

In the following table: LG = London Group, EM = Expert Meeting, TM = Technical Meeting, IS = International Seminar. Names in bold: meeting to elect the chairman.

Place	Date	Meeting	LG Chair	UNCEEA Chair
Geneva, Switzerland	23-25 February 1983	First UNEP-World Bank workshop	NA	NA
Washington, USA	5-7 November 1984	2nd UNEP-World Bank workshop		
Paris, France	30 Sept.-2 Oct. 1985	3rd UNEP-World Bank workshop		
Washington, USA	17-18 Nov. 1986	4t UNEP-World Bank workshop		
Paris, France	20-21 Nov. 1986	5th UNEP-World Bank workshop		
Paris, France	21-22 Nov. 1988	UNEP-World Bank expert workshop		
Publication of a summary of the previous meetings				
Special IARIW conference in Baden				
Publication of IEEA 1993				
London, UK	16-18 March 1994	1st LG		
Washington, USA	15-17 March 1995	2nd LG		
Stockholm, Sweden	May 1996	3rd LG		
Ottawa, Canada	17-20 June 1997	4th LG		
Fontevraud, France	25-29 May 1998	5th LG		
Canberra, Australia	15-19 Nov. 1999	6th LG		
Voorburg, Netherlands	7-11 May 2001	7th LG		
Rome, Italy	5-7 Nov. 2003	8th LG		
Publication of the Final Draft "IEEA 2003" (March 2004)				
Copenhagen, Denmark	20-21 Sept. 2004	Preliminary consultation of the UNCEEA		
Copenhagen, Denmark	22-24 Sept. 2004	9th LG		
New York, USA	29-31 August 2005	Preliminary meeting of the UNCEEA		
New York, USA	19-21 June 2006	10th LG		
New York, USA	22 -23 June 2006	First UNCEEA		
Johannesburg, South Africa	26-30 March 2007	11th LG		
New York, USA	5-6 July 2007	Second UNCEEA		
Rome, Italy	17-19 Dec. 2007	12th LG		
New York, USA	26-27 June 2008	Third UNCEEA		
Brussels, Belgium	29 Sept.-3 Oct. 2008	13th LG		
Canberra, Australia	28 April-1 May 2009	14th LG		
New York, USA	24-26 June 2009	Fourth UNCEEA		
			Rob Smith (informal leader)	
			Mark de Haan (1st mandate)	Walter Radermacher
				Peter Harper (1st mandate)

Place	Date	Meeting	LG Chair	UNCEEA Chair
Wiesbaden, Germany	30 Nov - 4 Dec 2009	15th LG	Mark de Haan (2nd mandate)	Peter Harper (1st mandate)
New York, USA	23-25 June 2010	Fifth UNCEEA		
Santiago, Chile	25-28 Oct. 2010	16th LG		
Copenhagen, Denmark	11-13 May 2011	EM on Ecosystem Accounting		
New York, USA	15-17 June 2011	Sixth UNCEEA		
Stockholm, Sweden	12-15 Sept. 2011	17th LG		
London, UK	5-7 Dec. 2011	EM on Ecosystem Accounts		
Melbourne, Australia	16-18 May 2012	EM on Ecosystem Accounts	Joe St. Lawrence	Peter Harper (2nd mandate)
Adoption of the SEEA FC				
Rio de Janeiro, Brazil	11-13 June 2012	Seventh UNCEEA		
Ottawa, Canada	2 - 4 Oct. 2012	18th LG		
New York, USA	27 Nov - 29 Nov 2012	International Seminar		
Adoption of the SEEA EEA				
New York, USA	20-21 June 2013	Eighth UNCEEA		
London, UK	12-14 Nov. 2013	19th LG		
New York, USA	25-27 June 2014	Ninth UNCEEA		
New Delhi, India	15-17 Oct. 2014	20th LG		
New York, USA	28-30 April 2015	Forum of Experts on SEEA EEA		
New York, USA	24-26 June 2015	Tenth UNCEEA		
The Hague, Netherlands	2-4 Nov. 2015	21st LG		
New York, USA	22-24 June 2016	Eleventh UNCEEA		
Oslo, Norway	28-30 Sept. 2016	22nd LG		
New York, USA	19-21 June 2017	Twelveth UNCEEA		
San José, Costa Rica	17-20 Oct. 2017	23rd LG		
Revision of EEA starts				
Bonn, Germany	24-26 April 2018	EM on Ecosystem Valuation		
New York, USA	18-20 June 2018	Forum of Experts on SEEA EEA		
New York, USA	21-22 June 2018	Thirteenth UNCEEA		
Dublin, Ireland	1-4 Oct. 2018	24th LG		
New York, USA	22-24 January 2019	EM on Advancing the Measurement of ES		
New York, USA	24-25 June 2019	Fourteenth UNCEEA		
New York, USA	26-27 June 2019	Forum of Experts on SEEA EEA		
New York, USA	28-29 June 2019	TM on the revision of the SEEA EEA 2019		
Melbourne, Australia	7-10 Oct 2019	25th LG		
Online	16-18 March 2020	TM on Valuation and Accounting		
Online	June/July/Aug./Nov. 2020	Forum of Expert on SEEA EEA		
Online	6-9 July 2020	Fifteenth UNCEEA		
Online	05-12 Oct. 2020	26th LG		
Online	16-18 Nov. 2020	Extraordinary Meeting of the UNCEEA		
Adoption of SEEA EA			Sven Kaumanns	Bert Kroese (2nd mandate)

Appendix G. What is the SEEA and how has it evolved?

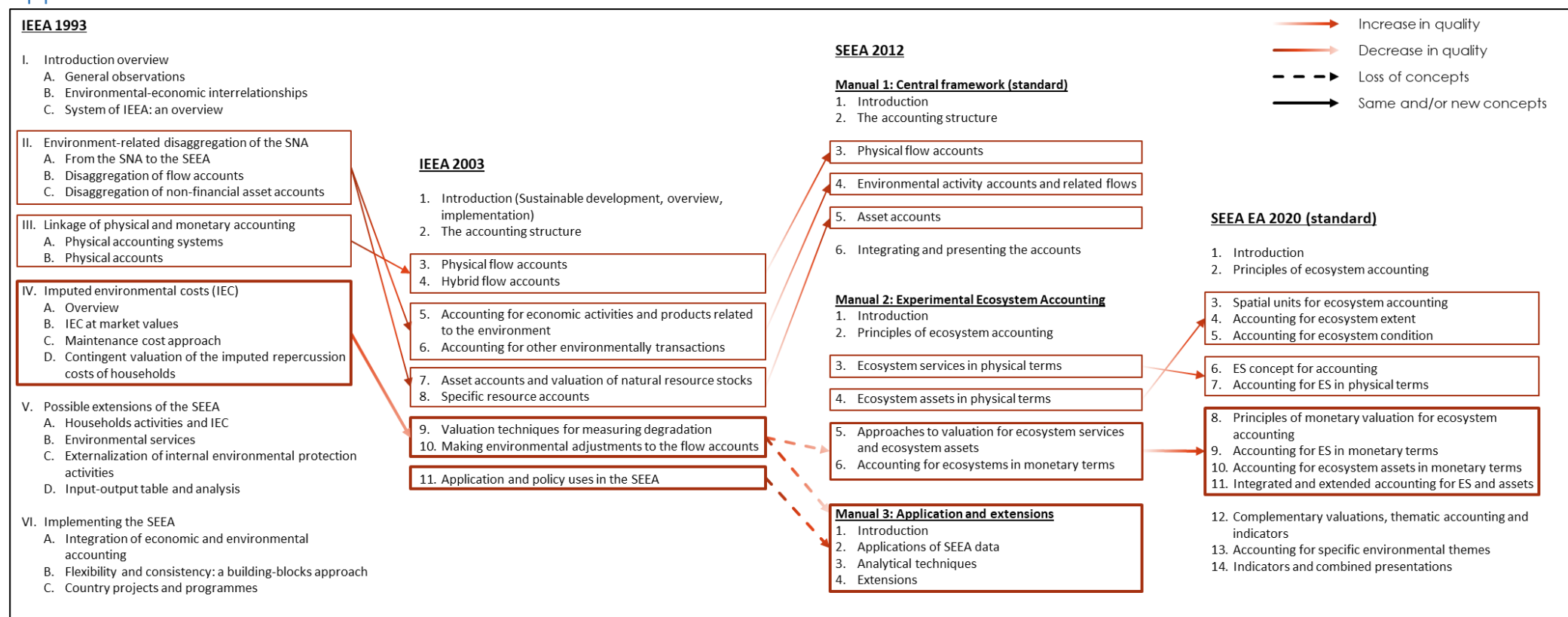


Figure 55 Qualitative evolution of SEEA versions

Legend: IEEA: integrated environmental and economic accounting; SEEA: system of environmental and economic accounting; SNA: system of national accounts; ES: ecosystem services. This figure shows the content of each manual. The chapters of main interest are highlighted by thicker lines. Solid arrows: concepts and ideas from the previous version can be found in the new one. Dotted arrows: loss of concepts and ideas. Darker lines indicate a shift to more structured, clearly explained or detailed information.

Appendix H. A diversion through the notion of heritage

In the French language, the notion of heritage has several meanings. The main ones are:

- "All the property inherited from ascendants or gathered together and kept for transmission to descendants" (CNRTL, n.d.).
- "All the assets and liabilities of a person (natural or legal) or group of persons, which can be valued in money, including assets (securities, claims) and liabilities (debts, commitments)" (CNRTL, n.d.)

And, by analogy, or figuratively:

- BA: "That which is transmitted to a person, a community, by ancestors, previous generations, and which is considered to be a common heritage" (CNRTL, n.d.)

As noted by Barrère et al (2005) the notion therefore oscillates between a strictly individual perimeter and an extension to groups. The concept, which originated in Latin in the 12th^e century, initially concerned private property that was received and then passed on to descendants. So there is not just a link with individual ownership. The latter is only a sort of obligatory passage for property that belongs above all to a family. In the same vein, in the seventeenth century, we read "tous les biens de l'Église sont le patrimoine des pauvres" ("all Church property is the heritage of the poor") (CNRTL, n.d.). In 1794, Abbé Grégoire defined the notion of "patrimony of the nation". (Boulad-Ayoub, 2012) considerably extending the group that owns this property, which must be preserved from destruction and "vandalism".

It was again at the time of the French Revolution that a counter-movement took place around this notion. The law reworked it to restrict it to "a legal support for individual market rights" (Barrère et al., 2005). This is reflected in the second definition above.

Economics takes up this concept, which it shares entirely. With no ties (particularly to the past and to one's lineage, and even less to the future), the individual is the sole owner of wealth, which is itself reduced to a monetary stock. Only that which can be valued falls within this framework (Barrère et al., 2005).

In French, it should be noted that the notion of inheritance, although linked to that of patrimony, does not make explicit either the potentially common dimension of what is received or that of retransmission to descendants. It is:

- In other words, "to inherit" (CNRTL, n.d.) that is, "to become the owner, possessor (of something); to receive (something) by right of succession, by inheritance" (CNRTL, n.d.)
- ES is "the estate left to a person on his or her death; inherited assets" (CNRTL, n.d.)

It is interesting to compare these terms with *heritage*, *patrimony*, *bequest* and *legacy*, as they are often used in the literature on the environment and ecosystem services. *Bequest* has the same meaning as *héritage*: "*money or property that you ask to be given to a particular person when you die*". (Oxford Advanced Learner's Dictionary, n.d.). *Legacy* has a very similar meaning, but opts for the point of view of the person who receives the goods: "*money or property that is given to you by somebody when they die*" (Oxford Advanced Learner's Dictionary, n.d.). (Oxford Advanced Learner's Dictionary, n.d.).

Unlike *bequest*, which has a Germanic root, *heritage* and *patrimony* come from French and Latin. These words appeared in French in the twelfth century and were translated into English in the thirteenth^e and fourteenth^e centuries respectively. (Etymonline, n.d.).

- While the English word *heritage* initially had the same meaning as the French word héritage, it has evolved up to the present day by taking on Abbé Grégoire's single meaning of patrimoine, but also introducing the idea of identity: "*the history, traditions, buildings and objects that a country or society has had for many years and that are considered an important part of its character*" (Oxford Advanced Learner's Dictionary, n.d.). (Oxford Advanced Learner's Dictionary, n.d.)
- *Patrimony* means "*property that is given to somebody when their father dies*". (Oxford Advanced Learner's Dictionary, n.d.)

For these two terms, the change from French to English means that the idea that the descendants are ultimately the recipients is lost; only the origin of the good is present in the definitions.

Appendix I. Debt and the future, clarifications

Here we take a look at the various components of ecological debt accounting and discuss their links with the notion of the future, of projection.

Impacts/observed assets: do not depend on the future. In particular, accounting is not supposed to make projections. This is a matter for other offices or institutions.

- ➔ We will therefore confine ourselves to estimating the debt for a past year, 2019, and not to making projections.

Preservation threshold: this can be static (not dependent on the future) or dynamic (dependent on the future). In the first case, it does not depend on the future or a trajectory, but is a fixed value. This approach is well suited to the micro level and if we are close to sustainability, but it is hardly tenable in the two opposite cases. A dynamic threshold follows a trajectory towards sustainability, which corresponds to the preservation threshold targeted in the long term, which will then be stable. The use of a dynamic threshold recognises that the current situation is a long way from sustainability. To draw an analogy with the financial world, we need to look at the restructuring of unsustainable debt. We can in fact consider that environmental neutrality is in fact the normal preservation threshold, but that it has been largely exceeded for several decades. Defining a dynamic threshold on the basis of the current situation is tantamount to accepting the losses of the past and accepting even more losses until we return to a sustainable level.

- ➔ In our case, this changes the threshold: either 0 (neutrality), or the current value, or the average over the last 10 years (possibly divided by 2, which is NNLT's intermediate target).

Amount of biophysical debt: mechanically, this may or may not depend on the future, depending on the type of threshold defined.

Amount of monetary debt: inevitably depends on the future, as the actions to be taken to settle the biophysical debt are estimated. Be careful here:

- We must not confuse 1° budgets, ecological debt scenarios drawn up within a management accounting framework (Business accounting) or public policy scenario, integrating future avoidance actions, with 2° the estimate of monetary debt, which excludes avoidance actions (opportunity costs), but includes real future expenditure (reduction or compensation).
- We need to be clear about the fact that, in order to pay off the ecological debt, there may be a timeframe different from that of macro-neutrality/threshold stabilisation. A priori, the debt contracted in year N must be paid off over a (much) shorter timeframe than the stabilisation of the preservation threshold. The year in which the debt is repaid is determined with the capital representatives. This is the point on which we need to be clear when making our estimates.
 - ➔ 1 to 3 years in general. This is determined by the timing of the (reduction) work and the compensation.

Appendix J. Complete classification of accounts by subsidy accounting type

Intitulé du compte	Lien avec dette envers une ME	Enjeu	Type d'action	Type subvention
11-Installation de traitement des eaux usées domestiques et assimilés				
1110-Epuration des collectivités locales	O	Préservation	Réduction	Préservation
1110-Etudes sur les stations d'épuration des collectivités locales	O	Préservation	Réduction	Préservation
1111-Ouvrages collectifs de traitement	O	Préservation	Réduction	Préservation
1112-Assainissement autonome	O	Préservation	Réduction	Préservation
1120-Etudes sur le traitement des eaux pluviales	O	Préservation	Réduction	Préservation
1121-Travaux de dépollution des rejets de temps de pluie	O	Préservation	Réduction	Préservation
1122-Appel à projets urbains exemplaires	O	Exploitation	Evitement	Evitement
1123-Réduction à la source des écoulements de temps de pluie	O	Préservation	Réduction	Préservation
12-Réseaux d'assainissement des eaux usées domestiques et assimilées et des eaux pluviales				
1210-Etudes sur réseaux d'assainissement	O	Préservation	Réduction	Préservation
1211-Création de réseaux d'assainissement	O	Préservation	Réduction	Préservation
1212-Réhabilitation et amélioration des réseaux d'assainissement	O	Préservation	Réduction	Préservation
1213-Branchements des particuliers	O	Préservation	Réduction	Préservation
1214-Travaux d'urgence réseaux d'assainissement	O	Préservation	Réduction	Préservation
24-Restauration et gestion des milieux aquatiques				
2410-Aménagements de rivière et préservation milieux aquatiques et humides	O/N	Divers	Divers	Cf. échantillonnage
2410-Etudes sur les milieux aquatiques et humides	O/N	Divers	Divers	Cf. échantillonnage
2411-Travaux de restauration des milieux	O/N	Divers	Divers	Cf. échantillonnage
2412-Travaux pour la continuité écologique	O	Préservation	Restauration	Préservation
2413-Acquisitions foncières de milieux aquatiques et humides	N	Exploitation	Production	Soutien activité env.
2414-Zones humides : changement de pratiques agricoles	O	Exploitation	Evitement	Evitement
2415-Acquisition matériel : milieux aquatiques et humides	NA	NA	NA	NA
2420-Entretien milieu aquatique	N	Exploitation	Production	Soutien activité env.
2420-Rivières et zones humides : animation et communication	N	Exploitation	Production	Soutien activité env.
2421-Travaux d'entretien des milieux aquatiques et humides	NA	NA	NA	NA
2423-Travaux d'urgence restauration de cours d'eau	NA	NA	NA	NA
2424-Travaux d'urgence entretiens milieux aquatiques	NA	NA	NA	NA
25-Eau potable				
2510-AEP des collectivités locales	N (Quantitatif)	Exploitation	Production (ress. eau)	Classique
2510-Etudes sur AEP des collectivités locales	N (Quantitatif)	Exploitation	Production (ress. eau)	Classique
2511-Lutte contre le gaspillage	O	Préservation	Réduction	Préservation
2511-Travaux sur la quantité en AEP	N (Quantitatif)	Exploitation	Production (ress. eau)	Classique
2512-Travaux sur la qualité en AEP	N (Quantitatif)	Exploitation	Production (ress. eau)	Classique
2513-Travaux sur la sécurité en AEP	N (Quantitatif)	Exploitation	Production (ress. eau)	Classique
2531-Irrigation : études, formation et animation	N (Quantitatif)	Exploitation	Production (ress. eau)	Classique
2532-Irrigation : études et travaux	N (Quantitatif)	Exploitation	Production (ress. eau)	Classique
18-Lutte contre la pollution agricole				
1811-Etudes préalables et travaux pollution élevage	O	Exploitation	Evitement	Evitement
1811-Maitrise pollution élevages : modernisation bâtiments	O	Exploitation	Evitement	Evitement
1821-Plan végétal environnement : acquisition de matériel	O	Exploitation	Evitement	Evitement
1830-Elevages	O	Exploitation	Evitement	Evitement
1831-Maitrise pollution élevage	O	Exploitation	Evitement	Evitement
1831-Pollution diffuse : changement de pratiques agricoles	O	Exploitation	Evitement	Evitement
1832-Communication, formation, sensibilisation en agriculture	O	Exploitation	Evitement	Evitement
1833-Techniques innovantes et expérimentations agricoles	O	Exploitation	Evitement	Evitement
1834-Purification de coquillages : investissements	O	Exploitation	Evitement	Evitement
1835-Plan Ecophyto II	O	Exploitation	Evitement	Evitement
1841-Soutien à l'agriculture biologique	O	Exploitation	Evitement	Evitement

13-Lutte contre la pollution des activités économiques hors agricoles				
1310-Epuration industrielle	O	Préservation	Réduction	Préservation
1310-Etudes sur l'épuration industrielle	O	Préservation	Réduction	Préservation
1311-Epuration industrielle	O	Préservation	Réduction	Préservation
1313-Dépollution industrielle : actions d'accompagnement	O/N	Divers	Divers	Cf. saisie manuelle
1315-Dépollution à la source - économies d'eau	O	Exploitation	Evitement	Evitement
1315-Dépollution à la source - technologies propres	O	Exploitation	Evitement	Evitement
1316-Dépollution Action groupée	O	Préservation	Réduction	Préservation
1320-Elevage	O	Accès	NA	Accès aux capitaux
1320-Etudes sur la réhabilitation des sites pollués	O	Accès	NA	Accès aux capitaux
1330-Centres traitement des déchets	O	Accès	NA	Accès aux capitaux
1330-Réduction rejets substances dangereuses : étude	O	Accès	NA	Accès aux capitaux
1331-Centres transfert DMS TPE	O	Exploitation	Evitement	Evitement
1331-Réduction rejets substances dangereuses : travaux	O	Exploitation	Evitement	Evitement
23-Protection de la ressource				
2310-Protection de la ressource : assistance et animation	N (Quantitatif)	Exploitation	Production (ress. eau)	Classique
2311-Protection de la ressource DUP : études et procédures	N (Quantitatif)	Exploitation	Production (ress. eau)	Classique
2312-Protection de la ressource DUP : travaux et indemnités	N (Quantitatif)	Exploitation	Production (ress. eau)	Classique
2313-Protection de la ressource zone non agri. : études et actions	N (Quantitatif)	Exploitation	Production (ress. eau)	Classique
2314-Protection de la ressource zone non agri. : matériels	N (Quantitatif)	Exploitation	Production (ress. eau)	Classique
2321-Acquisitions foncières	NA	NA	NA	NA
2330-AAC : études	NA	NA	NA	NA
17-Primes de performances épuratoires				
1711-AQUEx	O	Préservation	Réduction	Préservation
31-Etudes générales				
3110-Etudes	NA	NA	NA	NA
3110-Etudes générales d'orientation	NA	NA	NA	NA
21-Gestion quantitative de la ressource				
2110-Etudes sur les ouvrages structurants	NA	NA	NA	NA
2111-Travaux sur les ouvrages structurants	O	Préservation	Divers	Préservation
2120-Eaux superficielles	NA	NA	NA	NA
2120-Ruissellement et érosion : études	NA	NA	NA	NA
2121-Ruissellement et érosion : animation et travaux	N	Exploitation	Production	Soutien activité env.
2130-Etudes sur les économies d'eau	O (Quantitatif)	Exploitation	Evitement	Evitement
2131-Economies d'eau : travaux des collectivités	O (Quantitatif)	Exploitation	Evitement	Evitement
2132-Economies d'eau : travaux des industries	O (Quantitatif)	Exploitation	Evitement	Evitement
32-Connaissance environnementale				
3211-Réseaux de mesures sur le milieu	O	Accès	NA	Accès aux capitaux
34-Information, communication, consultation du public et éducation à l'environnement				
3404-Événements et partenariats de communication	N	Exploitation	Production	Soutien activité env.
3411-Participation à la consultation du public	N	Exploitation	Production	Soutien activité env.
3431-Classes d'eau	N	Exploitation	Production	Soutien activité env.
3432-Relais classes d'eau	N	Exploitation	Production	Soutien activité env.
3433-Partenariats éducatifs et classes d'eau non scolaires	N	Exploitation	Production	Soutien activité env.
3441-Soutien à l'emploi	O	Préservation	Divers	Préservation
3442-Soutien à l'emploi Fonctionnement	O	Préservation	Divers	Préservation
29-Planification et gestion à l'échelle du bassin				
2910-Animation de contrat global d'actions	N	Exploitation	Production	Soutien activité env.
2911-Etudes et animation des SAGE	N	Exploitation	Production	Soutien activité env.
33-Action internationale				
3311-Coopération et solidarité internationale	Hors champ	Hors champ	Hors champ	Hors champ
15-Assistance technique dans le domaine de l'eau				
1510-Animation technique d'assainissement	O	Préservation	Réduction	Préservation
14-Elimination des déchets				
1412-Elimination des effluents concentrés : actions groupées	O	Préservation	Réduction	Préservation
1421-Centres de valorisation boues et effluents concentrés	O	Préservation	Réduction	Préservation

Appendix K. When do we "produce" a new environment and when do we "preserve" one?

Here are some preliminary thoughts.

This question, linked to the classification of actions and subsidies between the categories "production of environmental goods" and "preservation action", does not exist in the CARE model. There is only the case of capital improvement, which occurs when a company chooses to restore an environment well beyond the natural capital preservation threshold. This is a kind of dividend paid to nature. The following year, the preservation threshold is increased by the same amount, and becomes the new benchmark.

However, the restoration and management of environments by General Government bodies is hardly a case in point. General Government produces many public goods, in the economic sense, at the more or less explicit and direct request of citizens. In National accounting, for example, green spaces, protected areas, the defence service and many health-related activities are all produced by public authorities.

To cross-reference this with environments managed with SNWA subsidies, we can refer to the (fictitious) example of Figure 56. This figure illustrates the fact that the environments considered to be in less than good condition correspond to a certain diversity of situations which are dealt with in different ways. If the impact on the environment being restored is so long-standing that the debt is considered to have been extinguished, or if it is not known whether an aquatic ecosystem already existed there (right-hand rectangle), the actions will be considered to be the production of an environmental good. If it is established that human impacts have taken place on an environment, without it being possible to say precisely who did it (light orange rectangle at bottom), the choice is made to mutualise the debt. In the opposite case (dark orange rectangle on the left), the choice is still to mutualise the debt for political reasons. Finally, the classic case is that which obeys the polluter-pays principle (dark orange rectangle on the right).

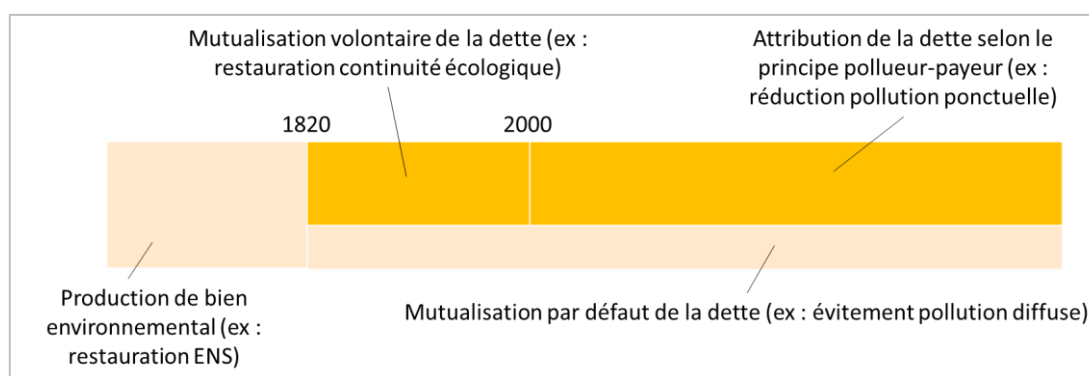


Figure 56 Fictitious cross-reference between accounting classification of activity and date of deterioration

Legend: the size of the boxes represents the surface areas of habitats (these are fictitious), the dark orange represents the surface areas of aquatic environments for which a clear responsibility can be attributed, the light orange those for which this is not possible. The date 1820 corresponds approximately to the start of the industrial era in France, and 200 is the date of publication of the WFD, which imposes ecological objectives of good status. ENS: espace naturel sensible (sensitive natural area).