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# Evaluating sustainability of farms: introducing a new conceptual framework based on three dimensions and five key properties relating to the sustainability of agriculture. The IDEA method version 4

Frédéric Zahm<sup>a\*</sup>, Adeline Alonso Ugaglia<sup>b</sup>, Jean-Marc Barbier<sup>c</sup>, Héroïse Boureau<sup>d</sup>, Bernard Del'homme<sup>e</sup>, Mohamed Gafsi<sup>f</sup>, Pierre Gasselin<sup>c</sup>, Sydney Girard<sup>a</sup>, Laurence Guichard<sup>g</sup>, Chantal Loyce<sup>g</sup>, Vincent Manneville<sup>h</sup>, Amandine Menet<sup>i</sup>, Barbara Redlingshöfer<sup>j</sup>

*a\* Corresponding and presenting author : frederic.zahm@irstea.fr Tel : +33 (5) 57 89 08 40*

*(a) Irstea, UR ETBX, 50 avenue de Verdun, F-33612 Gazinet Cestas, France*

*(b) UMR Save, Bordeaux Sciences Agro, 33170 Gradignan, France adeline.ugaglia@agro-bordeaux.fr*

*(c) UMR Innovation, INRA, CIRAD, Montpellier SupAgro, Université Montpellier, France*

*jean-marc.barbier@supagro.inra.fr pierre.gasselin@supagro.inra.fr*

*(d) Centre Ecodéveloppement de Villarceaux 95710 Chaussy, France heloise.boureau@bergerie-villarceaux.org*

*(e) Bordeaux Sciences Agro, 33170 Gradignan, France bernard.delhomme@agro-bordeaux.fr*

*(f) UMR LISST - Dynamiques Rurales, CNRS, UT2J, EHESS, ENSFA, Toulouse, mohamed.gafsi@educagri.fr*

*(g) UMR Agronomie, AgroParisTech, INRA, Université Paris-Saclay, F-78850, Thiverval-Grignon, laurence.guichard@grignon.inra.fr et chantal.loyce@grignon.inra.fr*

*(h) Institut de l'élevage (IDELE), 9 allée Pierre de Fermat 63170, Aubière, France vincent.manneville@idele.fr*

*(i) CEZ - Bergerie nationale de Rambouillet, France amandine.menet@educagri.fr*

*(j) INRA Agricultures urbaines / UMR SADAPT Paris, France - barbara.redlingshofer@inra.fr*

## **Abstract :**

*This article shows how new theoretical work on assessing sustainability of farms, carried out as part of a multidisciplinary approach, allowed a new theoretical framework to be developed, along with version 4 of the IDEA Method (Indicateurs de Durabilité d'une Exploitation Agricole). The first section divides existing studies taken from the literature into two types of indicator-based conceptual frameworks: those based on sustainable agriculture objectives, and those based on a systemic approach focusing on the properties of sustainability as applied to agriculture. The second part of this article explains the overall process of assessing farm sustainability based on the conceptual framework developed for IDEA v.4. The theoretical framework relates to strong sustainability, and agricultural multifunctionality (with 12 associated objectives). The method includes a systemic analysis of sustainability based on five properties observed within a sustainable farm: The ability to produce and reproduce goods and services; Autonomy; Robustness, Territorial embeddedness and Overall responsibility. These properties are then evaluated from 54 different indicators of agricultural sustainability. The method combines two mutually complementary approaches to assessing sustainability. The first of these examines the extent to which sustainability has been achieved (in agro-ecological, socio-territorial and economic terms) by aggregating indicators based on 13 components and a scoring system using sustainability "units". The second approach assesses the level of sustainability based on the five properties mentioned above. Indicators are aggregated hierarchically and organised based on 14 key categories. We show how the concept of properties has real educational value and can help to bring a new perspective to the field of sustainable farming.*

**Keywords:** *IDEA version 4, Sustainability assessment tools, Sustainable agriculture, Properties of sustainability, Farm sustainability indicators*

## 1. Introduction

Recent states of the art looking at ways of assessing agricultural sustainability (Schader *et al.*, 2014 ; Lairez *et al.*, 2015 ; De Olde *et al.*, 2016) have identified a whole plethora of different measurement tools and methods, including indicators, models, Life cycle assessment, multi-criteria analysis, cost-benefit analysis, and many more besides. At the heart of this diversity are a number of vastly different conceptual frameworks. Establishing such a framework is, of course, a vital first step in any analysis of farming sustainability. A conceptual framework relating to farming sustainability has four main objectives: (1) to present the general objectives of the method in question; (2) to explain the theoretical literature and underlying vision of the authors relating to sustainability (Hansen, 1996 ; Pope *et al.*, 2004 ; López-Ridaura *et al.*, 2002 ; Kates *et al.*, 2005); (3) to characterise the farming system being studied (parcel, crop system, entire farm, region, country, etc.) and identify its relationships with other meta-systems (Smith et McDonald, 1998 ; López-Ridaura *et al.*, 2005) and (4) to lay down the procedures to be used (creation of the method, methods to select and aggregate indicators). The IDEA method (Indicateurs de Durabilité d'une Exploitation Agricole or Farm Sustainability Indicators) is an indicator-based approach to analyze and assess the level of sustainability of a farm. First developed in the late 90s, it has been updated on two occasions (Vilain et al., 2008; Zahm et al.; 2008). In this article, we present the latest conceptual framework developed based on work carried out by the *IDEA Scientific Committee*. The originality of this framework lies in the combined use of two theoretical approaches to analyse farm and also agricultural sustainability.

The first part of the paper is a state of the art of the two possible theoretical approaches to assessing sustainability. The second part shows how the development of the IDEA v.4 conceptual framework has allowed the authors to make the following advances: establishing a new theoretical framework based on five properties of sustainability, taking into account new societal issues (food, circular economy, climate change, air quality, and sensible use of resources), and using a twin assessment table based on three key dimensions and five key properties for sustainability. This table makes use of a total of 54 indicators. The third part of the paper highlights the possible uses and future developments of IDEA v.4 and explains the key theoretical contributions made by this research.

## 2. Two types of indicator-based approaches to assess agricultural sustainability

The following literature review identifies two indicator-based conceptual frameworks (Binder, 2010) to analyse agricultural sustainability. The first uses an objective-focused approach, while the second is based on key properties of sustainability.

### 2.1 An assessment approach based on agricultural sustainability objectives

An objective-based, or “goal-oriented conceptual approach” (Von Wirén-Lehr, 2001) views agricultural sustainability as “the ability to satisfy objectives/goals” (Hansen, 1996). In other words, sustainable agriculture is defined by the goals it aims to achieve (Kates et al., 2005). Viewing sustainability in this way is connected both to the societal issues faced by farmers and farming in general (global sustainability) and

the internal goals which farmers aim to achieve (internal sustainability). This can be defined as the normative dimension of sustainability, or “a discussion of issues for which a consensus has been reached and a prioritisation of different actions needing to be taken” (Godard and Hubert, 2002). It points farmers in the right direction to achieve sustainability, based on pre-defined objectives (Sala et al., 2015). This approach depends on society’s values, and the perception of sustainability is framed by what society is aiming to achieve (Waheed *et al.*, 2009).

The literature review leads to the following conclusions: 1) the term “objective” does not appear uniformly throughout the literature. It is often replaced by other terms such as “issues”, “challenges”, “themes”, and “priorities”; 2) the term is based on a normative representation of sustainable development through its three official branches (environmental, social and economic), specifically the agricultural sector (UNCED, 1992), as defined by the UN as part of the 2030 sustainable development program. This program defines 17 “sustainable development objectives”, with objective number 2 relating to “promoting sustainable agriculture” (UN, 2015); (3) a very large number of “objectives” are defined. They can be either societal “meta objectives”, such as conserving natural resources and contributing to rural development, or more specific objectives such as protecting endangered species, improving working conditions, etc.

The advantage of a goal-driven approach is that it facilitates communication between scientists and stakeholders, bringing together work from these groups through multi-disciplinary cooperation (Sala *et al.*, 2015). In this case, the related intervention logic is much clearer for stakeholders implementing changes, because they can easily pinpoint the real action they need to take in order to achieve their particular objectives (Alkan-Olsson *et al.*, 2009). However, one of the downsides of this approach is that it can generate unnecessarily long lists of indicators if not combined with a systemic analysis of the farm being studied (Alkan-Olsson *et al.*, 2009). There is also the risk that the choice of goals may be too subjective, because of the likelihood that those laying down the goals may allow themselves to be influenced by their own personal values (Hansen, 1996).

## **2.2 An assessment approach based on properties of agricultural sustainability**

The second approach to assessing agricultural sustainability focuses on properties (also referred to as “attributes” or “principles”). This “system-based framework”(Van Cauwenbergh *et al.*, 2007) or System-based Property Oriented indicator Framework (SPOF) (Bockstaller *et al.*, 2007), aims to create a set of indicators based on their ability to clearly identify the status of a system based on the properties of sustainability (Altieri, 1987 ; Conway, 1987 ; Smyth et Dumanski 1994 ; Bossel, 1999 ; López-Ridaura *et al.*, 2005). This approach was used in the MESMIS research program (López-Ridaura *et al.*, 2002 ; Astier *et al.*, 2011), which identified seven key properties to analyse rural agricultural sustainability in Latin America: productivity, stability, reliability, resilience, adaptability, equity and autonomy. Bossel (1999) uses a similar approach, referring to “fundamental properties” to define the “internal viability of the system being studied” and the “contribution made by the system to the performance of other systems”. He measures a

system's contribution to sustainable development by the presence of six properties: existence, effectiveness, freedom, security, adaptability and coexistence.

The advantage of a property-based approach is that it remains generic and unaffected by the local context (Alkan-Olsson *et al.*, 2009). That said, some authors, such as Bockstaller *et al.* (2007) have noted that such an approach can be awkward to use in practice, because it takes considerable time to explain it to people who are unfamiliar with such methods.

### 3. Version 4 of the IDEA conceptual framework

#### 3.1 Theoretical framework

As the literature review shows, a conceptual framework based solely on normative objectives of sustainability (as shown in IDEA version 3: Vilain *et al.*, 2008 ; Zahm *et al.*, 2008) is necessary to give first farmers but also all other stakeholders a clear sense of the goals to be achieved. While version 4 does not abandon this approach, it (the approach) does not on its own allow a clear identification of the status of a system in terms of properties of sustainability. For this reason, IDEA v.4 also includes a **property-based approach**, the advantage of which is that it is not reliant on societal objectives, which are in themselves dependent on the local area in which they are embedded. This makes it possible to identify the sustainability of a farm in addition to simply highlighting the goals to be achieved. In theoretical terms, the IDEA conceptual framework is one of strong sustainability: *i.e.* it does not subscribe to the principle that generated capital can ever compensate for the loss of natural capital (Daly, 1990). It is based on the vision of sustainable agriculture and sustainable farms as defined in box 1.

Box 1: Agricultural and farming sustainability concepts as employed in IDEA v.4

**Sustainable agriculture** is a form of agriculture that is economically viable, environmentally friendly, humane, and socially fair. It contributes both to the overall sustainability of the local area in which it is practised, and to the achievement of global sustainable development objectives.

A **sustainable farm** is viable, acceptable, easily transmissible and readily reproducible. It is founded on a socially responsible approach. This approach depends on the choices made by farmers relating to the effects of their production methods on the quality of life of those living in the local area, as well as their contribution to realising global goals, such as fighting climate change, air quality, food safety, etc.

Source : Zahm *et al.*, 2015

To qualify the sustainability of a farm, we defined five key properties (Zahm *et al.*, 2015) based on the state of the art detailed above. The **Capacity to produce and reproduce good and services** (property 1) refers to a farm's long-term ability to efficiently produce and reproduce good and services, without eroding the natural and social resources it possesses. **Autonomy** (property no. 2) covers a farm's ability to produce goods and services from its own resources (inputs, human resources, and other production factors). It also includes its freedom to make decisions, its capacity to develop independently, and the extent of its dependence on public instruments (financial support, quotas, subsidies, etc). **Robustness** (property no. 3) is a farm's ability to adapt to environmental, social, and economic fluctuations, and to deal with new conditions and/or disruption and external shocks. This property encompasses the concepts of resilience,

adaptation, and flexibility. The **Territorial embeddedness** (property 4) means the ability of a farm to contribute to the co-production of local resources. It also highlights the nature and extent of market and non-market connections created with the local area, local residents, and stakeholders. **Global responsibility** (property no. 5) refers to the extent of a farm's commitment to a global approach, taking into account the environmental and social consequences of their mode of operation. This commitment is grounded in values of ethics and equity. As with territorial influence, this property does not focus exclusively on the farm itself, but also examines the impact of its actions at higher levels of organisation.

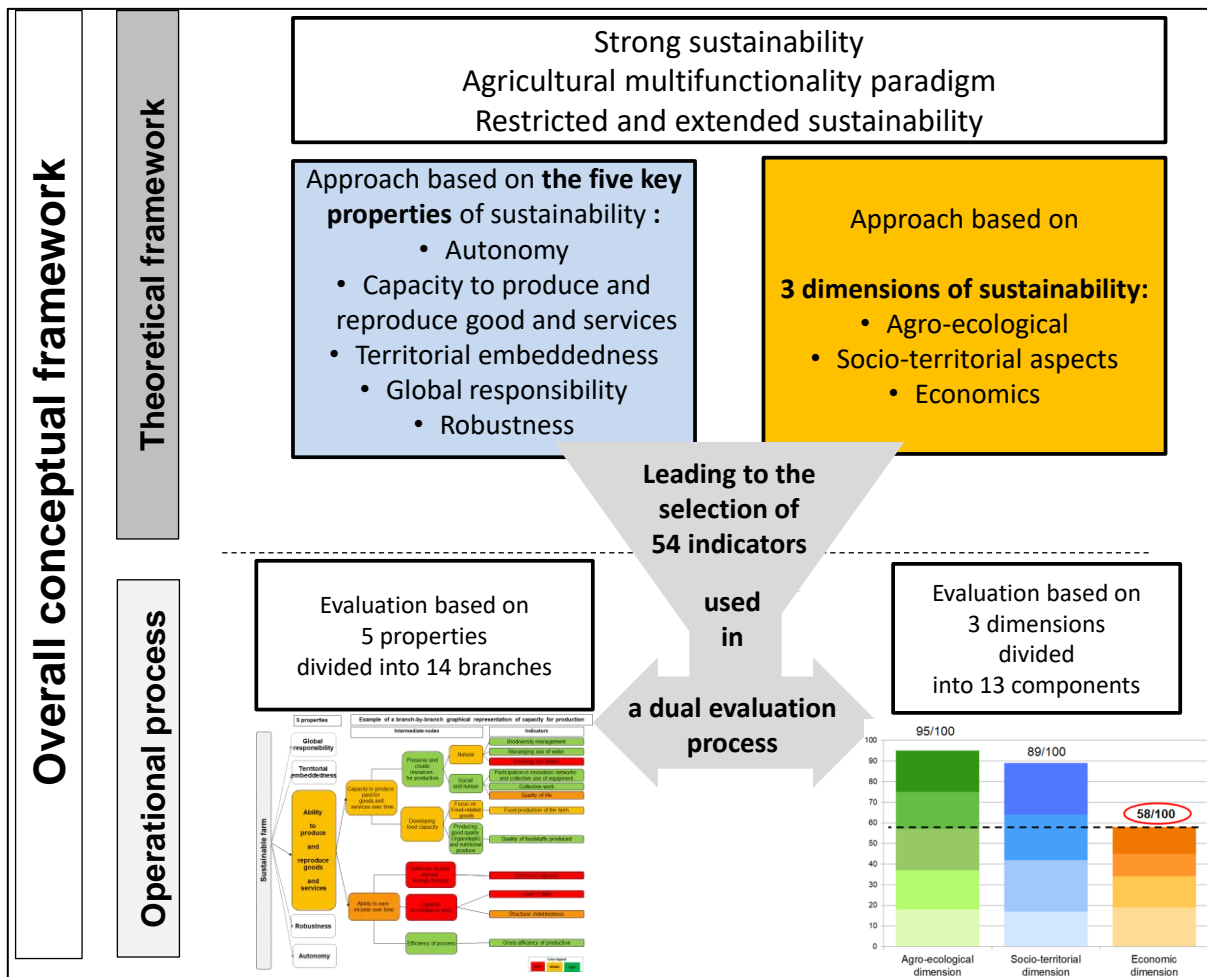
The conceptual framework also makes use of the concepts of (i) restricted sustainability and (ii) extended sustainability to identify the societal objectives of farms which also contribute to sustainable development on a larger scale (territory, local authority area, country, and the rest of the world) (Terrier *et al.*, 2013). These five properties are divided according to these two sustainability concepts, as shown in the table below:

Table 1: Five properties and 12 objectives of sustainable agriculture organised according to our two sustainability concepts

Sustainability concept	5 properties	12 objectives based on three key concepts of sustainable development
Restricted Sustainability	Capacity to produce and reproduce goods and services	1. Ensure the economic viability and long-term survival of the farm
	Autonomy	2. Contribute to quality of life
	Robustness	3. Maintain independence and freedom to act
Extended Sustainability	Territorial embeddedness	4. Make ethically responsible commitments
		5. Generate and share knowledge and know-how
		6. Ensure the health and wellbeing of livestock
	Global Responsibility	7. Preserve natural resources (biodiversity, soil, water, air)
		8. Preserve non-renewable resources
		9. Preserve and/or develop landscapes
		10. Deal with the challenge of climate change (through mitigation and adaptation)
		11. Contribute to food safety and sovereignty
		12. Contribute to employment and territorial development

The entire IDEA v.4 conceptual framework is shown in Figure 1.

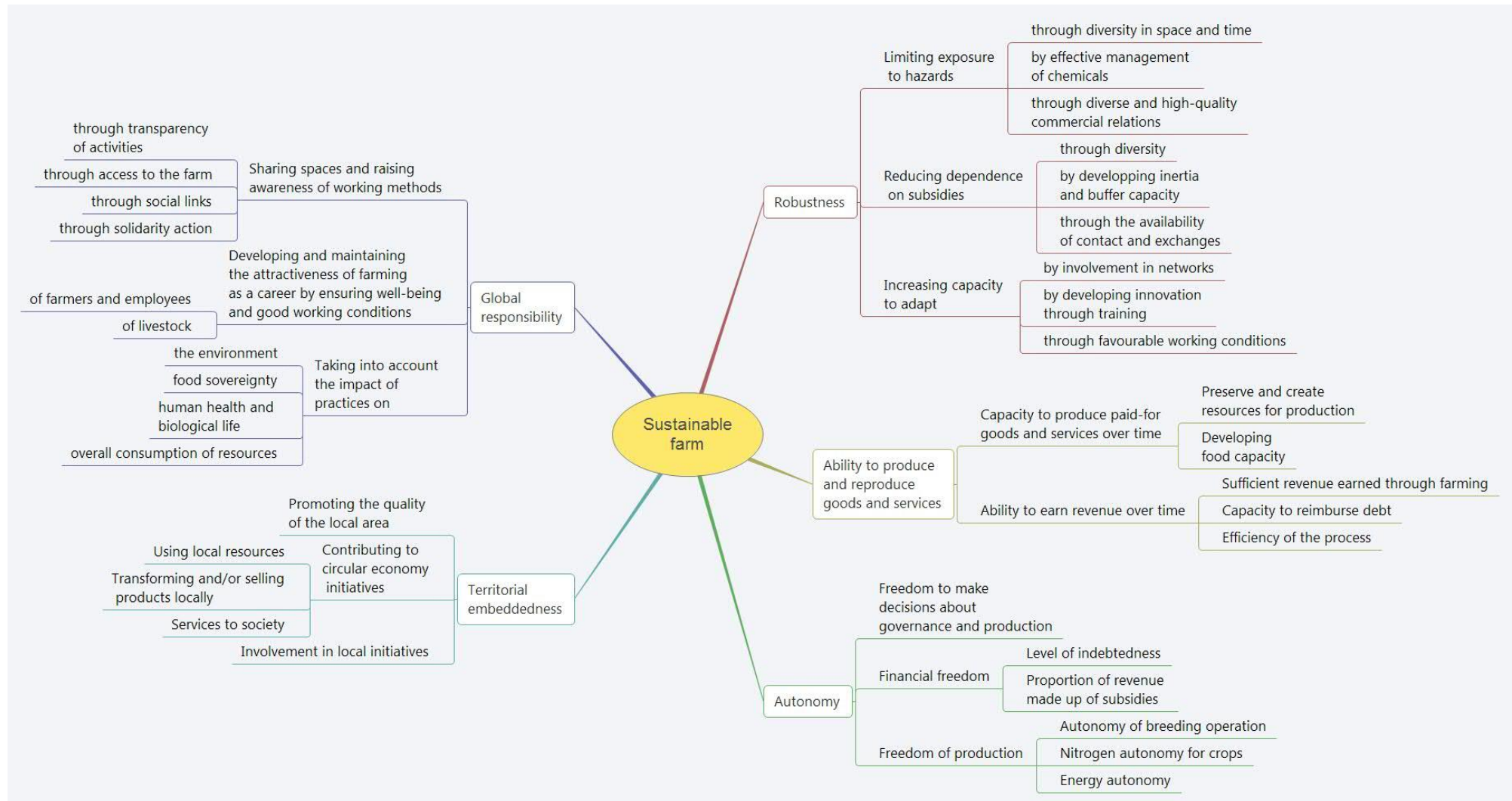
Figure 1: Overview of the conceptual framework for IDEA v.4



### 3.2 Operational process

The operation application of the IDEA v.4 conceptual framework is founded on three key elements. The first is the definition and creation of indicators based on three principles: (i) compatibility with the relevant theoretical framework, (ii) ensuring good quality indicators, based on recognised standards (Reeds *et al.*, 2006) (relevance, principle of parsimony, sound scientific grounding, fair assessment, measurability, educational value, transparency, and ease of interpretation based on benchmark thresholds), and (iii) ease of use for farmers, advisors, and students. The second element is the creation of a heuristic chart based on the five key properties of sustainability (Figure 2), combined with the 12 key objectives, which in turn lead to 54 different indicators. The third and final part of the operational process is the use of two complementary methods of evaluation, as shown below.

Figure 2 : heuristic chart showing the five properties of a sustainable farm developed by the IDEA version 4





### 3.3 Evaluation based on the three key dimensions of sustainability

This approach involves organising 54 indicators in such a way as to display a level of sustainability based on the three normative dimensions of sustainable development: agro-ecology, socio-territorial aspects, and economics. These are organised into thirteen components: five components concerning the agroecological dimension, four components for the socioterritorial dimension and four dimensions for economic dimension, as shown in table 2. The higher the score (between 0 and 100), the more sustainable the farm is.

The final sustainability level of the farm is the lowest score out of all three dimensions, bearing in mind that the method is based on the principle of “strong” sustainability (e.g. a score of 58/100 for example for a farm, see Figure 3). Within each dimension, indicators are aggregated by component. These components each have three functions: (1) theme-based organisation of the 54 selected indicators (table 2), (2) weighting each component within each dimension, and (3) compensating sustainability of the indicators contained within one component.

The dimension score is the cumulative number of basic sustainability units for the different indicators in the scale after weighting and aggregating the individual indicator scores within each component. Each dimension scale goes from 0 to 100 units of sustainability (table 2) and there is a ceiling value of units for each component (between 20 units to 35 units depending the different components). Maximum scores are set for each indicator in order to set an upper limit on the total number of sustainability units for each component and dimension (100 units). There is a final sustainability score for each of the three dimensions (see example in figure 3) with an equal weight between the 3 dimensions (see table 2).

From experience following the many tests of use of the three previous versions of the IDEA method (Zahm et al., 2008, Vilain et al., 2008; Rousselet, 2011), by applying a such system of ceiling to each component, the sustainability of many different farms can be assessed, taking into account the fact that they cannot all be covered by a single socio-technical model. Because of the vast range of local contexts and production systems in which farms operate, each will use a different combination of actions and take its own path to achieving sustainability. By displaying the information in this way, farmers can see areas where there is still progress to be made.

An example of this aggregation process is shown in figure 2 below. It concerns a farm with a score of 94 sustainability units for the agroecological dimension, 89 units for the socio-territorial dimension and 58 units for the economic dimension.

Figure 3: example of assessment evaluation based on three dimensions and a further 13 components for a farm

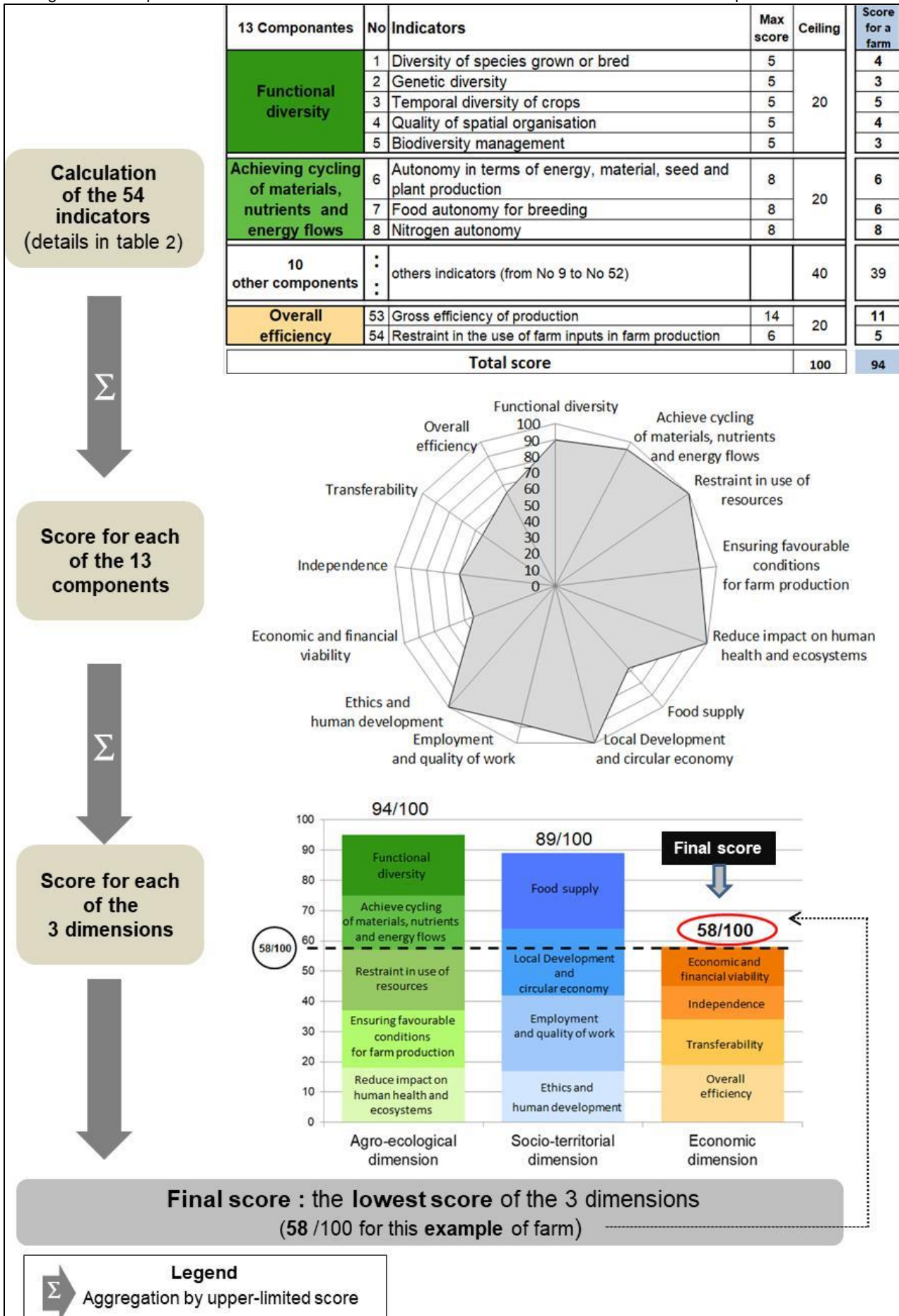


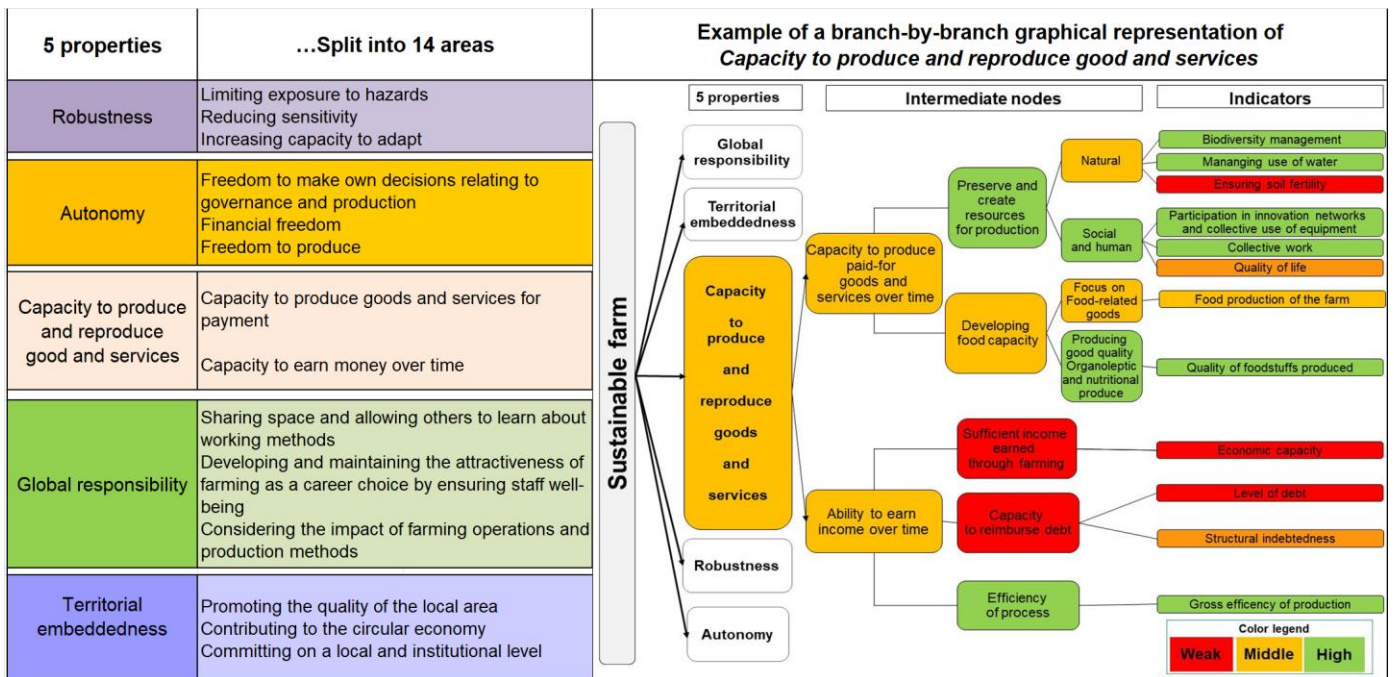
Table 2 : Global assessment IDEA grid showing the three-dimensional approach with its 13 components of sustainability and score –IDEA version 4

13 components	54 indicators	Score	Ceiling
<b>Title of components</b>	<b>Agro-ecological dimension (20 Indicators)</b>	<b>Max score</b>	<b>Ceiling</b>
<b>Functional diversity</b>	Diversity of species grown or bred	5	20
	Genetic diversity	5	
	Temporal diversity of crops	5	
	Quality of spatial organisation	5	
	Biodiversity management	5	
<b>Achieving cycling of materials, nutrients and energy flows</b>	Autonomy in terms of energy, material, seed and plant production	8	20
	Food autonomy for breeding	8	
	Nitrogen autonomy	8	
<b>Restraint in use of resources</b>	Restraint in the use of water and resource sharing	8	20
	Restraint in the use of phosphorous	8	
	Energy restraint	8	
<b>Ensuring favourable conditions for production</b>	Managing use of water	8	20
	Ensuring soil fertility	8	
	Ensuring continued health of crops and livestock	4	
	Protecting availability of production equipment	4	
<b>Reduce impact on human health and ecosystems</b>	Reducing impact of production on water quality	5	20
	Reducing impact of production on air quality	5	
	Reducing impact of production on climate change	5	
	Reducing the use of pesticides	5	
	Reducing veterinary treatment of livestock	5	
<b>Total</b>		<b>100</b>	
<b>Title of components</b>	<b>Socio-territorial dimension (23 Indicators)</b>	<b>Max score</b>	<b>Ceiling</b>
<b>Food supply</b>	Food production of the farm	5	25
	Contribution to world food balance	5	
	Quality of foodstuffs produced	5	
	Loss and waste	5	
	Social, hedonic and cultural links to food	5	
<b>Local Development and circular economy</b>	Commitment to local contractual environmental initiatives	5	25
	Local services	3	
	Development of short supply chain or local products	5	
	Protection and development of local resources	5	
	Preservation of local heritage (buildings, local know-how and natural resources)	3	
	Accessibility of space	3	
	Management of non-organic waste	3	
	Participation in innovation networks and collective use of equipment	3	
<b>Employment and quality of work</b>	Contribution to employment and human resource management	6	25
	Collective work	6	
	Intensity and quality of work	6	
	Reception, hygiene and safety	5	
	Training	5	
<b>Ethics and human development</b>	Local social action and solidarity	7	25
	Extent of transparency	7	
	Quality of life	7	
	Isolation	7	
	Animal well-being	3	
<b>Total</b>		<b>100</b>	
<b>Title of components</b>	<b>Economic dimension (11 Indicators)</b>	<b>Max score</b>	<b>Ceiling</b>
<b>Economic and financial viability</b>	Economic capacity	20	35
	Level of debt	12	
	Structural indebtedness	6	
<b>Independence</b>	Diversity of production	10	25
	Diversification and contractual relationships	10	
	Reliance on subsidies	6	
	Contribution of revenue from outside the farm	4	
<b>Transferability</b>	Economic transferability	15	20
	Likelihood of future survival	8	
<b>Overall efficiency</b>	Gross efficiency of production	14	20
	Restraint in the use of farm inputs in farm production	6	
<b>Total</b>		<b>100</b>	

### 3.4 Evaluation based on our five key properties of sustainability

In this approach, the 54 indicators are structured around our five key properties, which are themselves divided up into fourteen different branches (Figure 4). One of the key strategic choices made was not to aggregate the scores of each of the five properties into an overall sustainability score. They are aggregated only within each property. The reason why they are aggregated in this way is that a more “overall” style of aggregation does not adequately identify potential actions to be taken for each individual property. By looking at them individually, it is possible to work with farmers to improve the areas of their operation identified as being the least sustainable. The second methodological choice was to include an ascending system of aggregation, working up through the different intermediate nodes of the 14 branches making up each property, as show in Figures 2 and 4. The third strategic choice was to use hierarchical qualitative aggregation, making use of the DEXi multi-criteria decision application (Bohanec *et al.*, 2008). This application attaches three pre-programmed classes of sustainability (low, medium, high) to each indicator. Results can also be displayed for the intermediate nodes, as shown in the diagrams in Figure 4.

Figure 4 : Second assessment based on the five properties of agricultural sustainability



## 4. Discussion

The new IDEA v.4 conceptual framework was developed based on the following objectives: (1) ensuring it remained a useful teaching aid while introducing a new theoretical approach based on properties of sustainability, (ii) maintaining its scientific credibility by including new scientific knowledge gained since the last version 3, (iii) maintaining the key operational features recognised by the existing user base. A number of new societal issues have also been included: food, the circular economy, climate change, air quality, and restraint (low) in use of resources.

While the two complementary approaches used in the IDEA v.4 have now been finalised, both in terms of the conceptual framework and their indicators (components/dimensions and branches/properties), there is still work to be done on their practical application. For the three-dimension approach, the evaluation grids have now been completed (see Annex 1), and a working system has been developed to automatically input data and generate the two diagrams, as shown in Figure 2. This works through Microsoft Excel. A number of modifications and improvements were made to this approach following a trial period from 2015 to 2017, where 61 farming systems were studied, ranging from livestock breeding and crop-livestock, to arable crops (used for the dimensions) and viticulture (used specifically for the economic dimension). These sites are characterised by very different soil and climate types (Nouvelle Aquitaine, Brittany, Midi-Pyrénées, and Rhône-Alpes) and varied collective and individual dynamics. For the five-property approach, the decision rules for aggregating the indicators will be finalised as part of the ACTION research program (CASDAR 2017-2021) and will make use of the contingency matrix contained within the DEXi application.

Our first operational tests have shown that the “properties” and “dimensions” methods complement each other well when used together, providing a clear training tool to teach agricultural sustainability, as well as a fast and efficient way to display the overall sustainability of a farm (via qualitative analysis of the property branches) without having to collect all data from each indicator. The next key task will be to finalise a clear, operational aggregation table. It would also be interesting to look at whether this generic analytical framework could be applied to farming systems outside of Europe. It would also be interesting to examine possible uses of IDEA v.4 within the process of advising agro-ecological transition.

## 5. Conclusion

This new conceptual framework makes the following contributions to the field: (i) an explanation of the notion of “properties” within a farming system and an integrated understanding of the complexities of such systems, as suggested by Lopez-Ridaura *et al.*(2002), (ii) a reference for a transparent normative evaluation system for farms, based on twelve objectives divided up according to their relevant theoretical frameworks (extended and restricted sustainability), and (iii) a way of evaluating a farm’s sustainability through two modes of interpretation: the first through the three dimensions of sustainable development, and the second through the properties attributed to a sustainable farming system.

The next research goals will be to work with stakeholders to examine the extent to which IDEA’s twin dimension/property can be used to inform and advise agro-ecological transition, particularly in identifying levers for actions. The CASDAR ACTION research project will look specifically at these issues.

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