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## **Between hard protection measures, nature-based solutions, and managed retreat: Adapting coastal areas to sea level rise in the Netherlands and France**

**Abstract:** Faced with the risk of submersion and erosion along their coastlines, both France and the Netherlands have long relied on the introduction of ‘hard’ protection measures to tackle sea level rise. However, this approach has gradually begun to be reconsidered due to the adverse side-effects and decreased effectiveness that such protection measures may have in light of the increasingly significant impact of climate change on shorelines. New policy instruments such as nature-based solutions (NBSs) need to be found, but a lack of funding, resistance from local actors, and high population densities often impede the implementation of these instruments. While path-dependent solutions tend to be favoured in the short-term, more radical solutions such as managed retreat could prove necessary in the long run.

**Keywords:** adaptation to climate change, coastal areas, erosion, sea level rise, submersion

## **Zwischen natürlichen Klimaschutzlösungen, harten Schutzmaßnahmen und Verleugnung: Anpassung an den Meeresspiegelanstieg in den Niederlanden und Frankreich**

**Zusammenfassung:** Angesichts des Risikos von Überflutungen und Erosion an ihren Küstenlinien haben sowohl Frankreich als auch die Niederlande lange auf „harte“ Schutzmaßnahmen gesetzt, um dem Meeresspiegelanstieg zu begegnen. Dieser Ansatz wird allmählich überdacht und natürlichen Klimaschutzlösungen (Nature-based solutions, NBS) mehr Beachtung geschenkt. Die Anpassung an den Klimawandel in Küstengebieten erfordert indessen einen Multi-Level Governance-Ansatz, da lokale Akteure allein nicht in der Lage sind, die sich stellenden rechtlichen, finanziellen und ökologischen Probleme zu bewältigen. Dieser Aufsatz bietet eine vergleichende Perspektive auf die Erneuerung des Ansatzes zur Anpassung an Überflutungs- und Erosionsrisiken in Küstengebieten in den Niederlanden und in Frankreich und hebt die damit verbundenen Governance-Herausforderungen hervor. Während beide Länder zu einer adaptiven Strategie übergegangen sind argumentiert dieser Aufsatz, dass die jeweiligen Initiativen eine Reihe von Fragen offenlassen und dass, was die Auswirkungen des Klimawandels auf die Küstenlinien betrifft, nach wie vor eine Form von Verleugnung fortbesteht.

**Stichworte:** Anpassung an Klimawandel, Küstengebiete, Erosion, Meeresspiegelanstieg, Überflutung

### **1 Introduction**

Rising sea levels (i.e. ca. 20 cm worldwide on average between 1901 and 2018) pose an unprecedented challenge for the many urban areas located near the coast. By 2050, one billion people are expected to be exposed to coastal risks worldwide (Merkens et al., 2016). The main risks involve submersion, coastal erosion, endangered ecosystems (especially beaches), increasing salinity in aquifers, and the weakening of water drainage systems (IPCC, 2019). By 2150, the sea could be 5 metres above its current level (IPCC, 2021), with large variations from region to region. This momentum has led many countries around the world to initiate coastal adaptation strategies, especially when major urban centres are directly affected (Bongarts Lebbe et al., 2021).

On the European continent, rising sea levels are already causing coastal erosion in several EEA Member States (EEA, 2020), and submersion is occurring more frequently, especially in France, Belgium, the Netherlands, Spain (Lopez-Gutierrez et al., 2016), and northern Italy (Alfieri et al., 2017). While sea level rise in the Netherlands has been slightly below the global average in recent years, the country is expected to experience a continued rise in sea levels. The National Meteorological Institute (KNMI) predicts that this increase could reach 2 metres if the Paris Agreement is implemented, and 3 metres otherwise. Furthermore, if parts of the Antarctic ice sheet become unstable, sea level rise could increase considerably after 2050. KNMI estimates that whatever initiative is taken, sea levels will continue to rise after 2100. By around 2300, an increase of a few metres (i.e. 0.3–3.0 m for the 2 °C scenario, and 1.5–7.0 m for the hottest scenario) cannot be ruled out. Sea levels on the southern part of the Dutch coast could be 25–80 cm higher in 2071–2100 than they were in 1981–2010 (KNMI, 2015).

In France, 22% of coastal areas (i.e. 20,000 km) are subject to erosion (Secrétariat d’État à la Mer, 2023). Along 270 km of the French coast, erosion is occurring at an average speed of 50 cm per year, with no coastal region being spared. Depending on the given scenario, between 5,000 and 50,000 dwellings could be at risk by 2100. Over the past 50 years, about 30 km<sup>2</sup> of land has disappeared in France due to coastline retreat (Jouzel and Planton, 2022).

Most often, responses to coastal erosion or submersion risks fall into three general categories: ‘hard’ protection measures, such as building protection blocks; ‘soft’ protection measures or adaptive approaches, which involve changes to human activities; and managed retreat (IPCC, 2021). Both France and the Netherlands have long relied on the introduction of ‘hard’ protection measures to address coastal erosion, but nature-based solutions (NBSs) have attracted greater attention over the last 20 years. Such a paradigm shift is not merely a technical issue since it may affect land use practices in addition to local development perspectives. Moreover, NBSs could prove difficult

to implement in high-density populated areas. Resistance from local actors as well as associated costs are additional obstacles that must be overcome. Most importantly, NBSs could prove insufficient when it comes to addressing submersion risks. New coastal management practices might be required, and managed retreat could become an option to consider in some areas if solutions are planned and managed properly.

In the present paper, we begin by highlighting the challenges faced in both the Netherlands and France before discussing implemented policy instruments. We then conclude with the need to explore further pathways (e.g. managed retreat) in order to address sea level rise (SLR) associated with climate change.

## **2 Material and methodology**

In line with the IPCC definition (2001), we define ‘adaptation to climate change’ as a response to the impacts of climate change with the aim of mitigating these impacts and increasing the ability of individuals, organisations, and institutions to adjust their behaviour accordingly. We selected the Netherlands and France because both countries are particularly exposed to coastal erosion and have introduced NBSs.

In the case of the Netherlands, the risk of flooding is enshrined in the history of the country. The term ‘*Waterwolf*’ was coined in Middle Ages and expresses the fear caused by ‘the sea wolf in a country traditionally exposed to tidal pressure in the North Sea and to the flows of several major rivers (Gueben-Venière, 2015). The first attempts to exploit fertile lowlands despite the risk of flooding still resonate in the current landscape. For example, artificial dwelling mounds known as ‘*Terpen*’ that were built in order to provide safe ground during storm surges or high tides are still visible. On these *Terpen*, intensive agriculture was developed, whereas livestock farming prevailed in the surrounding areas.

From the 12<sup>th</sup> century onwards, the drying of large lake surfaces allowed people to live on an increasingly significant area of reclaimed land. Polderisation changed the landscape in Zeeland, where 22,000 ha were taken back from the sea between 1640 and 1665. Finally, in less than 500 years, 190,000 ha were polderised, representing 4% of the country’s current area. Moreover, 60% of the current area of the Netherlands would be flooded regularly without protection measures, and 9 million people would be affected (Ministerie van Infrastructuur en Milieu, 2015). Most of the country’s population and two-thirds of its economic activities are exposed to the risk of submersion or flooding because one-third of the country’s territory lies below sea level.

In addition to its location along the coastline of the North Sea, Holland is crossed by three international rivers (i.e. the Meuse, the Rhine, and the Escault), the flow of which may vary sharply. Moreover, due to the drainage of peatlands and areas reclaimed from the sea, the expansion of built-up areas, salt mining, and gas extraction, a subsidence phenomenon that can reach several centimetres per year affects the country’s coastline (Stouthamer et al., 2020). The management of the coastline is thus now more than ever a matter of national security.

In France, storms have also raised awareness of the risks of living along the coastline. Several such floods have caused many fatalities, including in 1972, 1977, 1984, and 1990. Storm Viviane in Picardie (in northeast France) in 1990 caused the most severe submersion in the 20<sup>th</sup> century and led to a sudden subsidence process in some areas (Bafail, 2022). In the following years, several other storms occurred, including the Xynthia in 2010 (which caused 53 deaths). In Wissant (Pas-de-Calais), Ciara caused dunes to retreat by 30 metres in February 2020 (La Fabrique Ecologique, 2020). In the southwest of the country, Soulac-sur-Mer is currently registering one of the most spectacular examples of coastline retreat of between 4 and 8 metres per year.

In order to discuss the merits and the limits of both NBSs and managed retreat when it comes to addressing erosion and submersion risks in the Netherlands and France, the present paper draws on empirical data that comprise a legal and policy framework analysis of grey literature and media articles. This framework also relies on semi-structured interviews with local officials (in The Hague in the Netherlands and in Charente-Maritime in France) and with Dutch and French water agencies.

## **3 Benefits and limits of NBSs in the Netherlands and France**

### **3.1 Nature-based solutions as a new paradigm against coastal erosion**

Confronted with SLR, countries around the world have introduced different policy instruments. Building ‘hard’ protection measures such as storm surge barriers, seawalls, and breakwaters is common practice, but such works can amplify soil subsidence and change the natural accumulation of sediments through tides, waves, and winds (Speybroeck, 2006). Moreover, these works can shift erosion to other parts of the coast (Cooper et al., 2020) and turn beaches into ‘rock and concrete’ coasts (Hollander et al., 2023). As a consequence, coastal habitats can be affected (Gittman et al., 2016), and natural coastal zones can become narrower (‘coastal squeeze’) and lose their capacity to both maintain biodiversity and protect coastal areas. In case of violent weather events, the destruction of such protection measures may lead to catastrophic events for the local communities that these measures are supposed to protect. As the measures provide these communities with a (possibly illusory) feeling of security, they may even impede adaptive policies and practices.

Hence, there is a need to implement different approaches that can protect shorelines while preserving biodiversity. In the past 10–15 years, NBSs have become a favoured approach to tackling erosion processes and reducing flood risks because coastal protection has shifted from the concept of ‘building in nature’ to the concept of ‘building with nature’ (Van der Meulen et al., 2023). Beach nourishment, seagrass meadow restoration, and ecosystem restoration have thus all been promoted. NBSs are described by the International Union for Conservation of Nature (IUCN) as ‘actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits’ (IUCN, 2020). These NBSs indeed help in protecting the shoreline while reducing negative side-effects for coastal ecosystems (Spalding et al., 2014). Beach nourishment has become mainstream in many countries exposed to coastal erosion (Hanson et al., 2002), for example, in Australia (Jackson et al., 2013), the United States (Ludka et al., 2018), and South Korea (Chang et al., 2016) as well as in Europe (Pinto et al., 2020).

### 3.2 NBSs have become the new normal in the Netherlands

Of the 432 km of the Dutch coastline, 75% of the coast is protected by sandy elements (e.g. beaches, dunes), and 15% is protected by hard structures. Three subsets of the coastline can be distinguished: the southwest delta, with the estuaries along the rivers Meuse and Rhine; the central coast, which consists of a stretch of dunes and of defences; and the north, where the coast is protected by a set of islands (Wadden Sea).

Before 1990, *ad hoc* maintenance of sandy coasts and increasing awareness of coastal erosion was prioritised. In 1990, a new coastal policy white paper was published (Ministry of Infrastructure and Water Management, 1990) that paved the way for dynamic preservation of the coastline of the Netherlands. The Flood Defence Act of 1996 confirmed this decision to stop the retreat in favour of active coastline management (Lodder and Slinger, 2022). Maintaining the physical basis of the coast became a priority, with dunes being reinforced in order to serve as natural flood defences.

Sand nourishment has thus become the cornerstone of Dutch coastal management, and most of the delta has already been reshaped by land use policies aimed at protecting the shoreline. Rivers have been embanked, floodplains have been turned into polders, dunes are regularly reinforced by beach nourishment, and huge areas of land are now cut off from the sea by storm surge barriers. Every year, a total of 12 million m<sup>3</sup> of sand is added to the coast in order to maintain the 1995 coastline despite erosion and submersion risks (Lodder and Wang, 2019).

One of the most impressive illustrations of this approach has been the *Zand motor* (‘sand engine’) project, which was completed in 2011 along the coast next to The Hague and added 22 million m<sup>3</sup> of sand to the coast with the aim of slowing the erosion process along the entire coast of the country, at least until 2030 (Rijkswaterstaat, 2021). Waves sweep the sand via natural transport into protective barriers that stretch along the coast. The project combines integrated coastal management, population safety, and leisure activity development. At the same time, sand nourishment strategies are being improved. In the past decades, sand nourishment has mainly been practiced on beaches and dunes with an immediate effect; however, the effectiveness of this practice has rapidly decreased over time. Strengthening riverbanks has been favoured because the impact of this process is more spread over time and is less costly. Preference is thus now given to beach nourishment only if no alternative solution is available (Rijkswaterstaat, 2021).

Moreover, a multi-layered approach is required for cities located close to the seaside, such as The Hague, which is highly attractive partly due to its location close to the major urban centres of Rotterdam and Amsterdam. Almost 150,000 additional inhabitants are expected over the next two decades (Brand, 2014). As a result, new neighbourhoods are being built, some of which lie outside the city’s protection measures against flooding. Discussions have hence taken place within the municipality on finding trade-offs between development and resilience. Faced with the risk of flooding, the city has developed three lines of defence, with the first being beach nourishment. As a second line of defence, a multi-purpose boulevard was completed in 2013 that improved the aesthetic of the waterfront and protects the city from flooding via a kilometre-long dike that was built beneath it. Access to the beach is provided through stairs designed to break apart in a way that would not damage the wall supporting the promenade in the event of heavy waves. A third layer of protection consists of a sand strip outside the boundaries of the city. Furthermore, the drainage of streets was also improved.

The Hague is moreover protected from flood risks by dikes. However, more construction is taking place outside the protected area, with negotiations between the municipality and the local water board occurring regularly.<sup>1</sup> Accommodating new inhabitants has become increasingly difficult due to land scarcity, which has led to some innovative housing policies. For example, former fishing facilities have been turned into a residential area with commercial premises on the ground floor and flats on the upper floors. Finally, several canals go through the city, and remotely driven pumps help manage waterflow in case of high waters.

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<sup>1</sup> Interviews were conducted with local officials in September 2022.

### **3.3 From hard protection measures to NBSs: The case of France**

In France, hard protection measures have long prevailed as a means of protecting the shoreline and avoiding any change in land use policies. With the increase in erosion and submersion risks, a mixture of policies now prevails that includes hard protection measures and NBSs. Most importantly, the legal framework has been profoundly reformed in order to adapt local planning policies to climate change. Storm Xynthia specifically highlighted many shortcomings along the coast related to excessive urbanisation, a lack of maintenance of dykes, and delays in the implementation of risk prevention plans (RPPs) (Valadier and Richer, 2015).

The French approach is now enshrined in several strategies and laws (Rocle et al., 2021), such as the National Strategy for Integrated Coastline Management (2012), the National Flood Risk Management Strategy (2014), the GEMAPI (Management of Aquatic Ecosystems and Flood Prevention) Law (2014), and the Climate and Resilience Law (2021). The National Flood Risk Management Strategy has led to the identification of significant flood risks for 124 areas of land, each of which is committed to establishing flood risk mapping through RPPs. Most of the regulations related to these legal initiatives pre-suppose a partnership between state actors and local actors, whose prerogatives have become significant in land management areas (Prévost and Robert, 2016). Implementation at the local level may thus vary and has indeed been uneven across the country (Mineo-Kleiner et al., 2021).

The implementation of RPPs is not complete everywhere due to a lack of expertise and resources (La Fabrique Ecologique, 2019). The financial capacity of local actors is indeed a challenge given the investments needed to maintain defence systems, be they hard or nature-based. In France, the transfer of GEMAPI competences to local authorities in 2018 empowered these authorities to establish cooperation schemes tailored to specific local needs. However, research on the coastline of Normandy has shown that local actors do not always have the expertise or the financial resources needed to maintain flood control structures (e.g. dykes) (Douillard et al., 2021).

Lack of awareness and/or of political will to introduce measures that could limit urbanisation is a further challenge to coastal management policies. While the National Strategy for Integrated Coastline Management recommended creating regional observatories for coastline management back in 2012, the process was only initiated in Provence-Alpes-Côte d'Azur in 2018 even though the region faces both beach and cliff erosion (Claeys et al., 2017) as well as coastal floods. Moreover, the 1986 Littoral Law aimed to limit demographic pressure by regulating coastal urban planning more strictly but has had mixed results. According to the Observatoire du Littoral ('Coastal Observatory'), 11,5% of the new dwellings built in France between 1990 and 2006 are located in coastal areas, which represent only 4% of the French metropolitan territory (Cadoret, Lavaud Letilleul, 2013). Most importantly, path-dependent policy instruments such as hard protection measures and beach nourishment still prevail even though such approaches might prove obsolete in the long run.

## **4 Managed retreat as a pathway to be considered?**

While NBSs have recently attracted more support than 'hard' protection measures, they can trigger controversies, especially regarding sand nourishment. On the Italian Adriatic Sea, this practice has been the object of disputes between environmentalists and the tourist sector. Environmentalists oppose beach nourishment on biodiversity concerns, while the tourist sector expects everything possible to be done to prevent beaches from shrinking (Prati et al. 2016). Moreover, the effectiveness of NBSs at reducing erosion and flood risks – especially during extreme weather conditions (e.g. hurricanes, cyclones) – might not be well assessed everywhere (Vuik et al., 2018).

Managed retreat may increasingly often become the last resort, though among coastal adaptation options, it is likely the most controversial option. In the United States, social inequities have been exacerbated in many retreat policies (O'Donnell, 2023), and such policies have led to objections in many different countries, such as in Canada (Cottar et al., 2021) and in Europe (Seebauer and Winkler, 2020; Hofstede, 2019).

Place attachment demonstrated by residents and tourists alike raises questions regarding private property rights. In many cases, private property protection is a key concern that affects decisions related to both land use planning and adaptation policies (O'Donnell, 2023). As O'Donnell (2020) demonstrated, willingness to accept change is shaped by how people define, perceive, and interpret places, and these subjectivities complicate the implementation of any coastal management option. However, pursuing current coastal management policies could prove more and more costly, thereby making managed retreat an option worth considering.

### **4.1 Managed retreat in the Netherlands: Options and obstacles**

Beach nourishment as well as dikes and seawalls could require increasingly high investments along Dutch coastal areas. Closing inland areas off from the sea with dams, navigation locks, and sluices could be one option of protecting against the effects of climate change, but handling river discharge requires enormous pumping stations as well as large areas for temporary flood storage. A slightly different approach would consist of maintaining current connections with the sea. In such a case, SLR could have a significant impact upstream along rivers, thereby requiring extensive dike improvement programmes in order to protect inland areas from flooding and from the salinisation of surface waters (van Alphen et al., 2022).

For the Dutch delta, an alternative would be to stop raising flood defences along the sea and to accept more frequent flooding events in low-lying areas. While protection measures around cities could be reinforced, such an approach would mean relocating part of the population. However, since finding new solutions is important, the 2010 Delta Programme provides solutions for different scenarios up to the year 2050 (Ministry of Infrastructure and Water Management, 2021). Nevertheless, current policy instruments could prove partly obsolete in the event of the accelerated melting of ice at the poles (Haasnoot et al., 2020). Indeed, the level of sand nourishment that is needed to keep the coastline at its current level could be 20 times greater by 2050 than it is today. Dikes at sea are expected to have to close more often, and saltwater inflows would be larger, while population growth along the coastline would require greater supplies of drinking water.

A 'living with water' strategy would trigger societal and political debate because reclaiming land from the sea would represent an entirely different strategy for dealing with the effects of climate change (van Alphen et al., 2022). However, managed retreat is not a completely new strategy. An illustration of the paradigm shift that seeks to embrace – rather than resist – rising water levels can be found in the *Room for the River* programme (Klijn et al., 2018), which allows certain areas to flood during periods of high waters. In the former Noordwaard region, polder houses were removed or relocated to outside the flood plain or to mounds (van Alphen, et al., 2022). In some areas, the restoration of salt marshes and the modernisation of coastal defences have led to the relocation of some activities. Managed retreat can obviously prove costly, but investments in protecting habitats and economic activities in low-lying flood-prone polders also induce significant costs that can create lock-in effects instead of supporting a paradigm shift in favour of more sustainable options.

## 4.2 Managed retreat in France

In France as in the Netherlands, managed retreat is difficult to conceive because coastal areas face three concomitant phenomena: high population densities, vibrant socio-economic activities (especially in the tourist sector, but also in logistics), and a dynamic demography. In France, the population density in coastal areas is 2.5 times higher than the national average, with a projected upward trend in the coming years (i.e. an increase of 4 million people by 2040) (MEDDE 2012). The share of artificial territories is 13.8% on average in coastal municipalities compared with 5.1% in the metropolitan territory, with 28.2% of coastal dwellings being located less than 500 metres from the shore.

In 2017, the *Conservatoire du littoral* ('Coastal Conservatory') launched 'Adapto' – a life project aimed at exploring flexible solutions for adapting natural coastal areas to erosion and submersion risks (Conservatoire du littoral, 2022). Based on around ten local examples of adaptation to coastal risks through relocation activities, the project demonstrated that creating space for wetlands to grow and for rivers at the expense of the existing infrastructure can enhance biodiversity while limiting flood risks. As provided for in Law 2003-699 as well as in the 2012 National Integrated Management Strategy for the coastline, the relocation of properties and infrastructures has led to experiments on a voluntary basis (Chotard et al., 2021). However, the small number of affected residential dwellings says little about the possibility of implementing such policies on a wider scale.

Where public infrastructure is at stake, relocation operations do not face major obstacles. In Languedoc-Roussillon, the coastal road from Sète to Marseille was moved inland between 2003 and 2015 because the erosion process affected the shoreline. However, based on several case studies in Normandy, Mineo-Kleiner and Meur-Ferec (2015) noted that 'the actors involved do not necessarily share a common vision of what a relocation project can be' (p. 2). Conflicts are thus set to occur frequently among stakeholders with different views on – and interests in – coastal areas. Most importantly, no authority is able to provide the financial compensation that would be required for a large-scale relocation process. Following the Xynthia storm, the Court of Auditors estimated that the relocation of 800 households would amount to costs of EUR 300 million (Cour des comptes, 2012).

Resistance to relocation, doubts regarding the urgency of climate change (Birchall, 2020), and fatalism (Bertoldo et al., 2021) mean that local actors tend towards well-known practices and hesitate to commit to changes that would entail economic losses and that would thus face opposition from the local population. Belanche et al. (2017) revealed how in PACA, local economic actors, inhabitants (especially older individuals), and elected officials might be aware of the effects of climate change but hesitate to commit to changes that would alter the identity of the place with which they are familiar. As any paradigm shift might affect local development and even imply relocation, support of the economy – and especially support of tourism – prevails in many coastal areas, as shown in other regions, such as Brittany (Krien and Michel-Guillou, 2014).

Managed retreat indeed requires a fundamental change in perceptions of people's living place (Rulleau and Rey-Valette, 2021) as well as a widely shared understanding that the coastline is not permanent. In order to increase social acceptance, some solutions have been discussed in the literature, such as support for 'modern nomadism', which would consist of the temporary occupation of vulnerable areas, with priority given to buildings that can be easily dismantled in order to take account of uncertainties regarding the evolution of the coastline (Lambert, 2015). The principle was taken up in the Climate and Resilience Law, which grants the right to lease land in coastal areas until erosion risks become too acute (Bafoil, 2022). Progressively giving up property rights could also be an option (Lambert, 2015), with each generation losing part of these rights.

As O'Donnell (2023) noted, '[A] core challenge therefore for coastal climate change adaptation lies in how we think about, and treat, property'. Tensions between different public and private interests are indeed very likely, even in countries such as Australia, where coastlines have historically been idealised as egalitarian and have remained open and free (Thom, 2012). In the Netherlands, between 500,000 and 1,500,000 new dwellings are expected to be built by 2040 (Kabat et al., 2005). As in many other European countries, demographic and economic growth mainly benefits large cities that are located close to the coastline and on the lowlands. As a result, an increasing share of the population of the Netherlands is expected to live in areas that lie below sea level. Urban centres close to the coastline are growing even more as urban sprawl becomes less constrained since national regulations that protect green belts around major cities have been weakened. While the west of the country is economically and demographically dynamic, the entire territory is in fact vulnerable due not only to its topography, but also to its high population density (i.e. 500 inhabitants/km<sup>2</sup>). Hence, the decision was taken in 1990 to 'hold the line' and to invest in diverse policy instruments (especially sand nourishment) as much as is needed in order to stop coastal retreat. In some areas, however, it might be appropriate to mix different approaches with managed retreat.

Across France, between 5,000 and 50,000 buildings are threatened by the retreat of the coastline by 2100, which represents an estimated global real estate value of between EUR 0.8 and 8 billion (only for housing) (CEREMA, 2019). On the one hand, local populations are most often highly reluctant to leave their property and expect authorities to carry out coastal protection works. On the other hand, this situation may give rise to equity problems because the people concerned usually enjoy high standards of living without having to contribute massively to the public investment needed to protect their property. Linking geological studies and sociological surveys, Claeys et al. (2017) investigated the municipality of Carry-le-Rouet, where the highest-value luxury neighbourhoods are the most at risk of erosion but whose inhabitants tend to deny the risks associated with their property.

### 4.3 Social acceptance as a main obstacle

Exploring pathways for slowing coastline retreat via successive steps over time depending on the evolution of a given coastline might help in overcoming social resistance and in managing costs. The concept of dynamic adaptive policy pathways (DAPPs) (Haasnoot et al., 2021) as a planning process appears highly relevant in this context. The concept entails successive steps beginning with assessing vulnerabilities, followed by low-regret actions and analysis with stakeholders before large-scale relocations are envisaged.

Social acceptance of managed retreat could also improve in the context of the increasingly higher costs associated with climate change. With recurring damage, real estate value might decrease, thereby leaving no option other than managed retreat. However, being aware of the risks does not necessarily lead to rational decision-making. Indeed, real estate prices in coastal communities still do not reflect the risks associated with coastal erosion (Inspection générale des finances, 2019). Buyers of real estate in the immediate vicinity of the French coastline are required to be informed of the risks associated with the location of their property. However, the risk of ocean flooding or of erosion is generally less well understood than is the risk of river flooding, for which precedents can be referred to (Bafail, 2022).

This psychological dimension also plays out in the case of the Netherlands. The country has among the highest flood protection standards in the world, with 1-in-4,000-year to 1-in-10,000-year flow return period infrastructure, particularly around the country's main coastal cities (i.e. Rotterdam, The Hague, and Amsterdam) (Gerritsen, 2005). Whenever properties are affected by floods, national authorities usually step in with the Reimbursement for Damages Due to Disasters Act ('Wet tegemoetkoming schade bij rampen', or WTS). However, the amounts allocated are at the discretion of the state. Moreover, during the floods in Limburg in July 2021, the authorities indicated that this law would no longer be applicable in the event of floods that could be covered by insurance. Rising sea levels thus might have an impact on the long-standing issue of natural risk insurance coverage in the Netherlands (Jongman et al., 2014), which is currently very low.

In France, flooding gives rise to compensation through specific funds, but the erosion process – which is considered foreseeable – is not eligible for such funds. In 2014, the residence 'Le Signal' in Soulac-sur-Mer (Gironde) had to be evacuated due to shoreline retreat. No compensation was provided by the Fund for the Prevention of Major Natural Hazards ('Fonds de prévention des risques naturels majeurs'), which is also called the 'Barnier Fund' and was set up in 1995 to compensate expropriated inhabitants. This fund – which is financed by a levy on residential and car insurance contracts – operates only in the event of natural disasters. Since coastal erosion is not considered such a disaster, inhabitants had to go through a lengthy legal process. In the end, a specific decree was adopted by the National Assembly to allow for compensation, but state authorities opposed the idea of extending the protection offered by the fund to also cover coastal erosion.

Natural risk insurance coverage is much higher in France than in the Netherlands. However, the French solidarity-based system (in which all insured parties contribute to protection against disasters – regardless as to their risk exposure – through a 'natural disaster premium' collected on all building insurance contracts) might deter people from acting responsibly (Rulleau, Rey-Valette, 2015). As a matter of fact, the increasing costs of climate change regularly lead the authorities to look for new funding sources either through the greater involvement of the local government (Grislain-Létrémy and Villeneuve, 2015) or through tax reforms.

## 5 Conclusion

Along their coastal areas, the Netherlands and France are facing both increasing demographic pressure and SLR that require policy instruments that may affect local economic development. While 'hard' protection measures may prove ineffective in the long run, NBSs are being called for now more than ever, but they may go hand in hand with high costs because actions such as sand nourishment need to be repeated regularly. The present paper highlighted how both countries are introducing managed retreat in some areas and provided insights into the merits of such an approach as well into the obstacles it faces.

Managed retreat inevitably triggers difficult debates because it affects real estate value, and various obstacles – such as attachment to places, relocation costs, and the preservation of cultural assets – could prove difficult to overcome. The process has therefore been limited to some specific areas in both countries. Managed retreat is understood as a set of actions for dealing with the effects of climate change that are planned and managed in an orderly fashion, and the process may help to enable the anticipation and better acceptance of long-term transformations of coastal areas. As shown in this paper, such a policy requires a cross-sectoral approach because it is related to land use policies and to local communities' risk perceptions as well as to insurance regimes.

Coastal adaptation decisions often involve long-term investments (e.g. flood defences, land use changes, the introduction of new housing standards, relocation of infrastructures), and future options should remain open because the long-term impacts of climate change remain unknown (Hallegate, 2009). A stepwise retreat strategy implies a significant change of mindset, but if well managed, such a strategy can create new opportunities (e.g. for biodiversity protection) and limit the risks of forced retreat after extreme weather events.

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