Journal of Environmental Management 345 (2023) 118675

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Research article

The impact of coastal realignment on the availability of ecosystem services: gains, losses and trade-offs from a local community perspective

Vincent Bax [a,*], Wietse I. van de Lageweg [a], Teun Terpstra [b], Jean-Marie Buijs [b], Koen de Reus [a], Femke de Groot [a], Robin van Schaik [a], Merhawi Arefaine Habte [a], Joppe Schram [a], Tom Hoogenboom [a]

[a] Department of Technology, Water & Environment, Building with Nature Research Group, HZ University of Applied Sciences, Het Groene Woud 1, 4331 NB, Middelburg, the Netherlands

[b] Department of Technology, Water & Environment, Resilient Deltas Research Group, HZ University of Applied Sciences, Het Groene Woud 1, 4331 NB, Middelburg, the Netherlands

ARTICLE INFO

Handling Editor: Lixiao Zhang

Keywords:
Managed realignment
Depoldering
Intertidal ecosystem
Public support
Southwest delta
Zeeland

ABSTRACT

Coastal realignment is the procedure of repositioning or removing coastal defense structures to restore tidal flooding and facilitate the development of intertidal ecosystems in a previously reclaimed area from the sea. A key policy objective of coastal realignment is to increase ecosystem services provided by intertidal ecosystems and thereby contribute to human well-being. However, the social response to coastal realignment is often negative, raising the question as to what extent communities living nearby project locations recognize, value and benefit from the goods and services provided by restored intertidal ecosystems. In this study, we examine public perceptions of ecosystem services gains, losses and trade-offs associated with coastal realignment. We hereby focus on three coastal realignment case study locations in the Southwest delta, the Netherlands. Questionnaires were administered in nearby villages and the collected data (N = 261) were analyzed using random forest regression models. A notable outcome of this study is that local communities often consider coastal realignment interventions to decrease rather than increase the availability of ecosystem services. This points to a discrepancy between how coastal realignment is viewed from a policy perspective and a local community perspective. Changes in the availability of cultural ecosystem services were found to have the highest impact on the level of support for coastal realignment, while the importance attached to provisioning, regulating and supporting ecosystem services was notably lower. In consequence, to increase public support, it will be essential to minimize the loss of cultural ecosystem services, or better yet, find ways to increase cultural ecosystem services through coastal realignment, for instance by creating opportunities for recreation and tourism.

1. Introduction

For centuries it has been the tradition in low-lying countries such as the Netherlands to reclaim lands from the sea and establish dike infrastructure along the coastline. Dikes have been a primary means to manage flood risks, while many of the reclaimed land areas behind the dikes, known as polders, have been repurposed for agricultural production and human settlement (van der Ham, 2009). Land reclamations, dike constructions and other human developments in estuarine areas have resulted in the loss and degradation of intertidal ecosystems, such as salt marshes and tidal flats (Kennish, 2002; Murray et al., 2019). These ecosystems provide important ecosystem services, such as flood protection, nutrient regulation, opportunities for recreation and habitats for a variety of plant and animal species (Barbier, 2012; Deegan et al., 2012). On a global scale, between a quarter and half of all salt marsh areas have disappeared (Millennium Ecosystem Assessment, 2005). Also in the Netherlands, major losses have taken place over the past few decades, particularly in the Eastern Scheldt estuary in the Southwest delta (de Vet et al., 2017; Smaal and Nienhuis, 1992). To reduce the pressure on intertidal ecosystems, it will become increasingly important to shift from conventional dike infrastructure to alternative ways to protect the coast, particularly in the light of climate change. Sea-level rise will prompt the landward migration of the intertidal zone, causing the ecosystems to become squeezed between the sea on one side, and the

* Corresponding author.
E-mail address: v.a.bax@hz.nl (V. Bax).

https://doi.org/10.1016/j.jenvman.2023.118675
Received 10 March 2023; Received in revised form 28 June 2023; Accepted 24 July 2023
Available online 28 July 2023

hard coastal defences on the other (Doody, 2013; Pontee, 2013).

The introduction and adoption of the concept of nature-based solutions in coastal policies marks a paradigm shift in the approach to flood risk management (Warner et al., 2018). Conventional flood defences are no longer considered the sole solution to flood protection, but the use of hard structures is preferably combined or replaced with actions that protect, sustainably manage or restore the capacity of ecosystems to decrease the risk of flooding (Guerry et al., 2022). Under the umbrella of nature-based solutions, a range of alternative coastal defence strategies have emerged that contribute to flood risk management and the restoration of estuarine biodiversity jointly. One such strategy is the landward realignment of existing hard defenses to restore tidal flooding and facilitate the restoration of intertidal ecosystems in a clearly defined coastal stretch – usually within agricultural areas (de la Vega-Leinert et al., 2018; French, 2006). This is often referred to as coastal realignment, managed realignment or depoldering. Intertidal ecosystems, and in particular salt marshes, have the ability to dissipate the force of waves and provide a protective buffer to the realigned coastal defense (Huguet et al., 2018). This contributes to flood safety and potentially leads to a significant reduction in flood defence maintenance costs (Turner et al., 2007).

Much attention is being directed to the biophysical and ecological changes associated with coastal realignment (Brunetta et al., 2019; Burden et al., 2013; Petillon et al., 2014; Rotman et al., 2008). However, to facilitate coastal realignment interventions in the coming years, it is equally important to understand how these interventions are perceived by local communities and what factors shape their perceptions. In spite of providing significant nature restoration and flood protection benefits, previous studies have shown that deliberately "giving-up land to the sea" is controversial and gives rise to strong emotional reactions from the nearby population (Ledoux et al., 2005; Rulleau et al., 2017). Objections and concerns particularly revolve around the loss of the agricultural polder, along with the loss of livelihoods (Roca and Villares, 2012), cultural landscape elements (de la Vega-Leinert et al., 2018), community traditions (Liski et al., 2019), and place-related bonds (Agyeman et al., 2009) associated with the polder. Also institutional aspects raise concerns among the local population – for instance the lack of confidence in authorities and planning procedures has been reported to obstruct implementation processes around coastal realignment projects (e.g. Myatt et al., 2003; Roca and Villares, 2012). A key challenge from a project design and implementation perspective is to accommodate these concerns and counterbalance perceived negative impacts to allow for more socially acceptable and sustainable coastal realignment interventions.

On a more positive note, previous studies have shown that coastal realignment generally leads to a net gain in the availability of ecosystem services compared to the business-as-usual alternative (MacDonald et al., 2020). This suggests that the new (realigned) landscape and the ecosystem services provided by the new landscape have the potential to improve the well-being of the local community and contribute to supportive attitudes toward project development. It is therefore worthwhile to explore to what extent and under what circumstances local communities recognize, value and benefit from these ecosystem services. Yet, so far this has seldom been a topic of study, apart from a few notable exceptions (Chen et al., 2020; McKinley et al., 2020; Sherren et al., 2016, 2021; Zhao et al., 2023). In a similar manner, it remains open to question to what extent the ecosystem services provided by the new landscape counterbalance in the perception of the local community the forgone ecosystem services associated with the loss of the agricultural polder (i.e. the ecosystem services trade-offs), which is particularly relevant in the context of coastal realignment. This lack of understanding about how coastal realignment is perceived from an ecosystem services perspective hinders the design and implementation of future interventions that adequately balance ecological and water safety objectives with the interests and needs of the local community.

To address some of the abovementioned concerns, in this study we examine public perceptions of changes in the availability of ecosystem services as a consequence of coastal realignment. We focus on one ongoing and two fully established project locations in the Southwest delta, the Netherlands. A survey questionnaire was administered in the field among the population of villages nearby these project locations to compare how they perceive the availability of ecosystem services in the old situation (prior to coastal realignment) and in the new situation (post coastal realignment). Thereupon, we use regression techniques to examine how changes in ecosystem services availability affect public support for the intervention. The outcomes of this study point to societal gains, losses and trade-offs associated with coastal realignment, and suggest that there are ways to make coastal realignment more socially acceptable and beneficial.

2. Methodology

2.1. Study area

This study takes place within the context of the nature restoration efforts in the Eastern Scheldt and Western Scheldt estuaries in the Southwest delta, the Netherlands (Fig. 1a and b). Both estuaries are Natura 2000 protected areas and contain vast amounts of intertidal ecosystems. Over the past decades, these ecosystems have been deteriorating steadily, as a consequence of human actions such as the completion of the storm surge barrier in the Eastern Scheldt in 1986 and regular dredging activities in the navigation channels in the Western Scheldt to the port of Antwerp. As part of a strategy to halt and reverse the degradation of natural values and achieve the Natura 2000 goals, the Dutch government has identified potentially suitable locations for the implementation of nature restoration efforts, such as coastal realignment and the construction of breakwaters. In this study, we focus on three coastal realignment case study locations, including Rammegors, Perkpolder and the Hedwigepolder (Fig. 1c).

Rammegors is a nature reserve of about 145 ha, located in the Municipality of Tholen on the northeastern border of the Eastern Scheldt estuary. The Rammegors area was originally composed of estuarine intertidal ecosystems, because of its open connection with the Eastern Scheldt. With the construction of a dam (the Krabbenkreekdam located directly to the west of Rammegors) and the opening of a canal (the Scheldt-Rhine canal, located directly to the east of Rammegors) in 1972, the area was closed off from the Eastern Scheldt and gradually transformed into a brackish-freshwater wetland. In the decades that followed, the intertidal areas within the Eastern Scheldt became increasingly under pressure, as a result of coastal developments and the associated disturbance of the tidal volume, tidal current velocities and the overall sediment budget (De Vet et al., 2018; Van der Werf et al., 2019). To compensate for the loss and degradation of intertidal areas, a number of compensatory measures were implemented, one of which being the reintroduction of the tide in the Rammegors area. Consequently, in 2014, a tidal inlet was constructed in the Krabbenkreekdam to reconnect the Rammegors area with the Eastern Scheldt and allow for the development of saline intertidal ecosystems. As the Krabbenkreekdam remained in place, the Rammegors area continued to be an inner dike system. The intervention was subject to negative media attention and raised concerns among the nearby community, in particular about salinization-induced degradation of the surrounding agricultural areas and local freshwater resources.

Perkpolder is a previously reclaimed area located along the Western Scheldt in the municipality of Hulst. The Perkpolder area marks the site of an old ferry service. With the opening of a road tunnel below the Western Scheldt in 2003, the decision was taken to discontinue the ferry service and redevelop the ferry port site and the adjacent agricultural polders. The Dutch Water Management Authority (Rijkswaterstaat) was at the same time looking for suitable locations in the Western Scheldt to implement nature compensation measures, including coastal realignment. A collaboration between the municipal government, the Province,

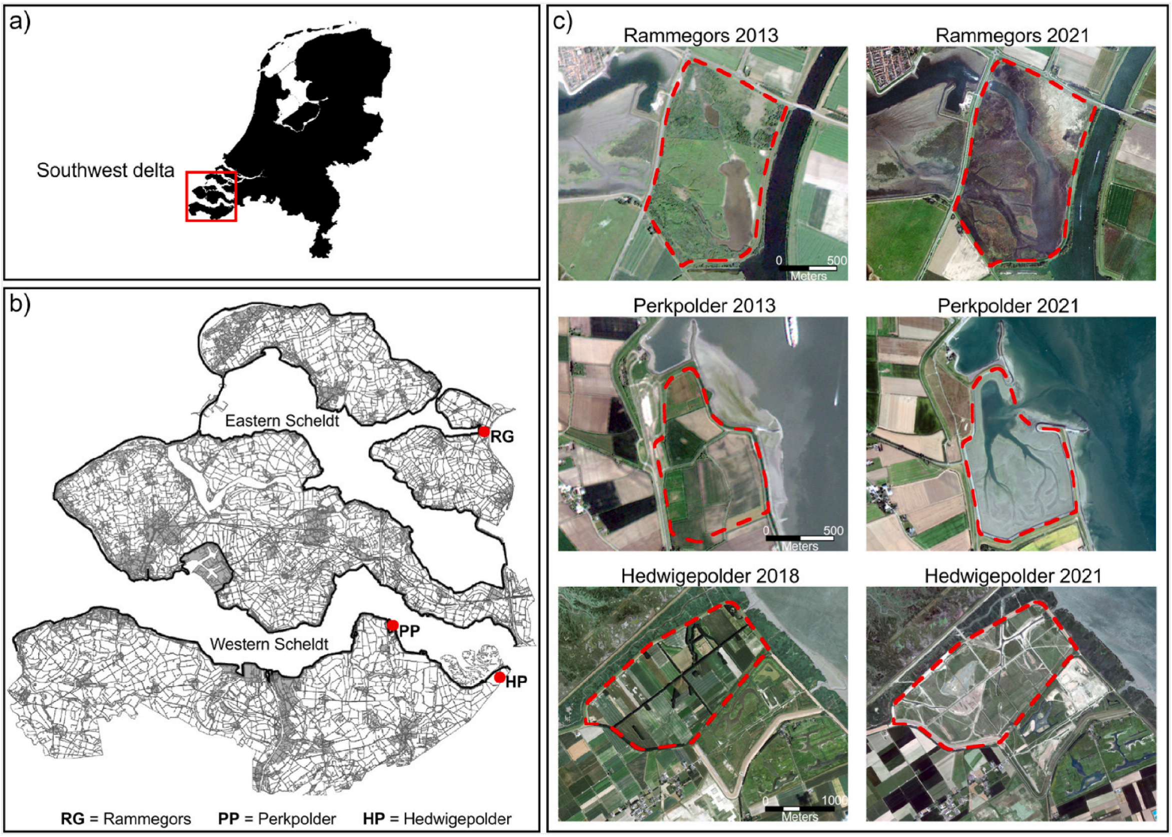

Fig. 1. Study area. a) Location of the Southwest delta in the Netherlands; b) Location of the Eastern Scheldt, Western Scheldt and the three coastal realignment case study areas. The bold black lines depict primary flood defenses; c) Satellite images of the three coastal realignment case study areas. The images of Rammegors and Perkpolder show the landscape prior to and post coastal realignment (in 2013 and 2021, respectively), whereas the images of Hedwigepolder show the landscape approximately 4 years and 1 year prior to coastal realignment (in 2018 and 2021, respectively).

Rijkswaterstaat and private actors eventually resulted in a broader spatial development plan for the Perkpolder area (van Buuren et al., 2012), which included the creation of a 75 ha estuarine nature reserve through a coastal realignment intervention, along with the development of new houses and a marina. A new sea defense was established further inland, after which the original primary defense around the agricultural polders was breached in 2015 to reestablish the tidal influence and facilitate the development of the estuarine nature reserve. Two years after the dike breach, it became clear that the soil substrates used to create the new sea defense contained heavy metals, causing pollution of the phreatic water and the nearby surface waters. While health and environmental risks were deemed negligible, the issue was broadly covered by the local and national media, leading to negative societal attitudes to the Perkpolder redevelopment initiative and concerns about the water quality among the local population.

The Hertogin Hedwigepolder (hereafter Hedwigepolder) is a former agricultural polder of 300 ha in the region of Zeeuws-Vlaanderen, located deep into the Western Scheldt estuary against the Belgian border. The area has been reconnected with the Western Scheldt through a planned dike breach at the end of 2022. At the time of conducting this research, the actual dike breach was still to take place, whereas the required preparatory activities such as the removal of trees and buildings and the construction of a new coastal defense further inland had already been completed. Hence, in the context of this study the realignment of Hedwigepolder is considered to be an ongoing coastal realignment intervention. As a result of the intervention, the Hedwigepolder and the adjacent Prosperpolder on the Belgian side of the border will gradually transform into an intertidal nature reserve to become part of the Saeftinghe marshes – the largest salt marsh Natura 2000 protected area in the Southwest delta (in Dutch: Verdronken land van Saeftinghe). The plans to convert the Hedwigepolder have been met with a great deal of resistance from the local community and led to extensive societal and political discourse about the need to give up land for nature restoration purposes. Over the years, several attempts have been made to circumvent the coastal realignment intervention, for instance through legal procedures initiated by property owners in the area or inquiry into alternative measures to achieve nature compensation objectives. The final decision on the destiny of the Hedwigepolder was taken by the Supreme Court of the Netherlands in 2018, ruling in favor of the coastal realignment intervention.

2.2. Data collection

We started out with a review of the scientific literature to collect published evidence on public attitudes to coastal realignment and comparable policy-induced landscape interventions. The results of this review were used as input for the conceptualization of a rigorous questionnaire instrument to measure the attitude toward the coastal realignment interventions in the Perkpolder, Rammegors and Hedwigepolder areas. By studying multiple case study locations in the Southwest delta, each with a different implementation status and context, we aimed to generate a comprehensive understanding about how coastal realignment is perceived by communities nearby project locations. A separate questionnaire was developed for each of the three case study locations with equivalent questions to allow for comparison between the different locations, while taking into account case study-specific information to provide context. A major part of the questionnaire centered around concepts from the psychological sciences, including place attachment, risk perception, trust and social norms. The outcomes of this part of the questionnaire are beyond the scope of the present study and will be reported and discussed in a forthcoming publication.

For the purpose of this study, we focus on one particular question about the perceived changes in the availability of ecosystem services as a result of the landscape transformation, as well as one question about the level of support for the coastal realignment intervention. More specifically, we asked respondents to indicate to what extent they perceive the availability of ecosystem services to be better in the old situation (prior to coastal realignment) or in the new situation (post coastal realignment), taking into consideration a list of 16 ecosystem services belonging to 4 categories (provisioning, regulating, supporting and cultural ecosystem services). Perceptions about the availability of each of these 16 ecosystem services were elicited through a rating scale, ranging from 1 (much better in the old situation) to 5 (much better in the new situation). The level of support for the coastal realignment intervention was evaluated based on one question consisting of three items – all of which were measured on a 5-point rating scale.

The questionnaires were administered across three villages in the surroundings of the coastal realignment project locations, including Sint Philipsland (~1 km from Rammegors), Kloosterzande (~1 km from Perkpolder) and Hulst (~10 km from the Hedwigepolder). We thoroughly instructed and supervised a team of six Master's students to administer the questionnaires, using a pre-established protocol and following widely accepted ethical principles in social science research such as the ones described in Kelley et al. (2003). In brief, the students were instructed to briefly introduce themselves, explain the purpose of the study and guarantee the confidentiality of the collected data and anonymity of the participant. All respondents provided consent to participate in the study and agreed to the use of their data for scientific purposes. We deployed a door-to-door sampling strategy, aiming to obtain a randomized and representative sample of the village's population. The students were instructed to distribute the questionnaires in various neighborhoods across the towns (e.g. in the town's center and at the outskirts), potentially increasing the representativeness of our samples compared to the target population. Inhabitants of rural areas directly surrounding the towns were not sampled, which could explain the low proportion of respondents employed in agriculture within our samples (see also the sample description in the results section). The questionnaires were left behind and collected at the end of the day (often referred to as a drop-off/pick-up data collection strategy (Steele et al., 2001)) to give respondents sufficient time to answer all questions and think about their answers. Residents unavailable to complete the questionnaire at the time of administration (e.g. in the circumstance they were too busy or not at home) were offered the possibility to complete the survey online via a weblink on a postcard. The administration of questionnaires in the field took place in a period of about 10 days (usually mornings and afternoons) in the months of December 2021 and January 2022. In Sint Philipsland we sampled 183 out of the approximately 882 houses in the village (21%). In Kloosterzande we sampled 224 out of 1645 houses (14%) whereas in Hulst we sampled 253 out of 5.578 houses (4%).

2.3. Data analysis

As a first approach to data analysis, we generated case study location-specific box and whisker plots for each of the 16 ecosystem services to explore and visualize how the local community generally perceives the landscape transformation to change the availability of ecosystem services. In addition, the one-sample Wilcoxon signed rank test was employed to examine whether differences in the perceived availability of these 16 ecosystem services are statistically significant.

The overall level of support for the coastal realignment intervention was evaluated by reducing the three separate questionnaire items into a latent variable. We conducted a factor analysis (principal components analysis with varimax rotation) along with a reliability analysis using IBM SPSS version 25, which showed a high correlation between each questionnaire item and the latent variable (factor loadings of >0.900) and a high scale reliability (Cronbach's alpha 0.943), see Table 1.

A random forest regression analysis was conducted to investigate how changes in the perceived availability of ecosystem services impact the level of support for the implementation of coastal realignment, largely following the modeling procedures employed by Bax et al. (2022) and Levi (2021). In brief, a random forest model is composed of a large number of decisions trees. The trees are generated based on randomly bootstrapped training samples, consisting of about two thirds of the initial dataset. Each tree in the random forest uses a randomized subsample of predictor variables to determine the split at each node. The remaining training data, about a third of the initial dataset (referred to as out of bag (OOB) data), is withheld from the construction of the trees and used to validate the accuracy of the model. The model produces relative importance metrics associated with each predictor variable included in the model, by measuring to what degree the percentage of Mean Square Error (MSE) of the model increases when OOB data for a given variable is randomly permuted, while leaving the other variables unchanged. A thorough theoretical description of the random forest model is available in Breiman (2001).

We specified a separate random forest regression model for each of the three coastal realignment project locations. The 16 ecosystem services whose perceived availability was rated in the old and new situation (i.e. prior to and post coastal realignment) were used as the predictor variables, while the level of support for the landscape transformation was used as the response variable. Demographic characteristics of respondents were considered as predictor variables but omitted from the final models because their explanatory power and contribution to model fit turned out to be limited. We conducted the analysis in R, using the randomForest package. The model requires the user to specify two tuning parameters: *ntree* (the number of regression trees in the model) and *mtry* (the number of randomly sampled predictor variables to determine the split at each node in the trees). The ntree parameter was set to 1000 to ensure stability of the variable importance assessment (500 is the default) while the value of the mtry parameter was determined by dividing the number of predictor variables (16) by 3, as suggested by Liaw and Wiener (2002). We used the variable importance function in the randomForest package to assess how changes in the perceived availability of ecosystem services as a consequence of the landscape transformation affect public support for coastal realignment.

3. Results

3.1. Sample description and level of support for coastal realignment

The data collection activities yielded a total of 325 surveys across the three case study areas, with an average response rate of 45%. Incomplete surveys were discarded (64), which resulted in a final sample of 261 surveys (Rammegors n = 83, Perkpolder n = 95 and Hedwigepolder n = 83). The size of the subsamples resulted in a margin of errror (MoE) at a 95% confidence level of 10.8%, 10.1% and 10.8% for the Rammegors, Perkpolder and Hedwigepolder areas, respectively.

Table 1
Factor analysis and reliability analysis on questionnaire items used to evaluate the level of support for coastal realignment in Rammegors, Perkpolder and Hedwigepolder.

Factors and questionnaire items	Factor loading	Standard deviation	Cronbach's alpha
Level of support (mean = 2.62; eigen value = 2.69; variance explained = 89.7%)			
I fully agree with the decision to implement coastal realignment	0.948	1.325	0.943
I fully understand the decision to implement coastal realignment	0.956	1.329	
I have very positive feelings about the decision to implement coastal realignment	0.938	1.274	

Fig. 2a provides an overview of the sociodemographic characteristics of the respondents included in our sample. The sociodemographic profile of the respondents is fairly similar across the three case study areas, with on average slightly more men (58%) than women (42%) and more than 80% of the respondents having completed some form of vocational education or holding a university degree. Respondents in the Hedwigepolder sample are slightly older and better educated than respondents in the Rammegors and Perkpolder samples. A minor share of the respondents within our samples is employed in a job related to agriculture (4% of the Rammegors sample, 3% of the Perkpolder sample and 5% of the Hedwigepolder sample; data were not included in Fig. 2). The demographic characteristics of the respondents within the sample were fairly similar to census data of the total population in the corresponding areas (see the appendix), with a slight overrepresentation of males (between 5% and 7%) and an underrepresentation of respondents below the age of 29 (albeit census and sample data are not entirely comparable due to differences in age class distribution).

Fig. 2b shows the variation in the level of support for coastal realignment across the three study areas. In the case of both the Rammegors and Hedwigepolder areas, more than 50% of the respondents were found to have a low or very low level of support for the coastal realignment intervention, while around 20% indicated to have a high or very high level of support. In contrast, the support for coastal realignment in Perkpolder was considerably higher, with more than 35% of the respondents having a high or very high level of support and 29% indicating to have a low or very low level of support.

3.2. Perceived gains and losses of ecosystem services

The colored boxplots in the left panels of Fig. 3 show for each of the three case study areas to what degree respondents consider the availability of ecosystem services to be better in the old situation (prior to coastal realignment) or in the new situation (post coastal realignment). The grey bar charts in the right panels of Fig. 3 show how perceptions about changes in the availability of ecosystem services impact the level of support for the landscape transformation. The random forest regression model statistics can be found in Table 2.

3.2.1. Rammegors

The coastal realignment intervention in the Rammegors area is generally perceived as having a negative impact on the availability of ecosystem services. More specifically, the transformation of the landscape is perceived to have caused a reduction in all provisioning ecosystem services ($p < 0.01$), supporting services ($p < 0.01$), cultural services ($p < 0.01$ or $p < 0.05$) and several regulating services, including carbon sequestration, soil quality regulation and pollination ($p < 0.01$). Some regulating services (e.g. erosion control and pollution control) are perceived to be comparable in the old and new situation, while flood risk reduction seems to have improved as a consequence of the landscape transformation – albeit the change is not statistically significant ($p > 0.05$).

Of all ecosystem services considered, in particular the changes in landscape aesthetics, opportunities for recreation and tourism and biodiversity were found to have a high impact on the level of support for the landscape transformation. The regression model statistics (Table 2) show that the change in the perceived availability of all ecosystem services together explains 31.5% of the variance in the level of support.

3.2.2. Perkpolder

The population near Perkpolder considers the coastal realignment intervention to have resulted in both positive and negative impacts on the availability of ecosystem services. In general, several regulating and supporting ecosystem services are perceived to have improved since the landscape transformation took place, including erosion control ($p < 0.01$), flood risk reduction ($p < 0.01$) and biodiversity (not statistically significant, $p > 0.05$). The availability of other regulating services has not noticeably changed (e.g. carbon sequestration and pollution control), whereas soil quality regulation has become worse after the landscape transformation ($p < 0.01$). When it comes to cultural services, the coastal realignment intervention has enhanced the opportunities for recreation and tourism ($p < 0.01$), potential for education and knowledge ($p < 0.05$), and landscape aesthetics ($p > 0.05$). On the other hand, the availability of provisioning ecosystem services seems to have declined in the perception of the local population, with the provisioning of food, fresh water and fibres and raw materials having become worse because of the landscape transformation.

The level of support for coastal realignment is particularly shaped by the changed availability of several cultural ecosystem services, including recreation and tourism as well as landscape aesthetics. Meanwhile, the changed availability of provisioning, regulating and supporting services appears to have a notably lower influence on the level of support for coastal realignment. The regression model statistics (Table 2) show that the perceived changes in ecosystem services induced by the landscape transformation explain 50.2% of the variance in the level of support for coastal realignment.

3.2.3. Hedwigepolder

The ongoing transformation of the Hedwigepolder area is generally

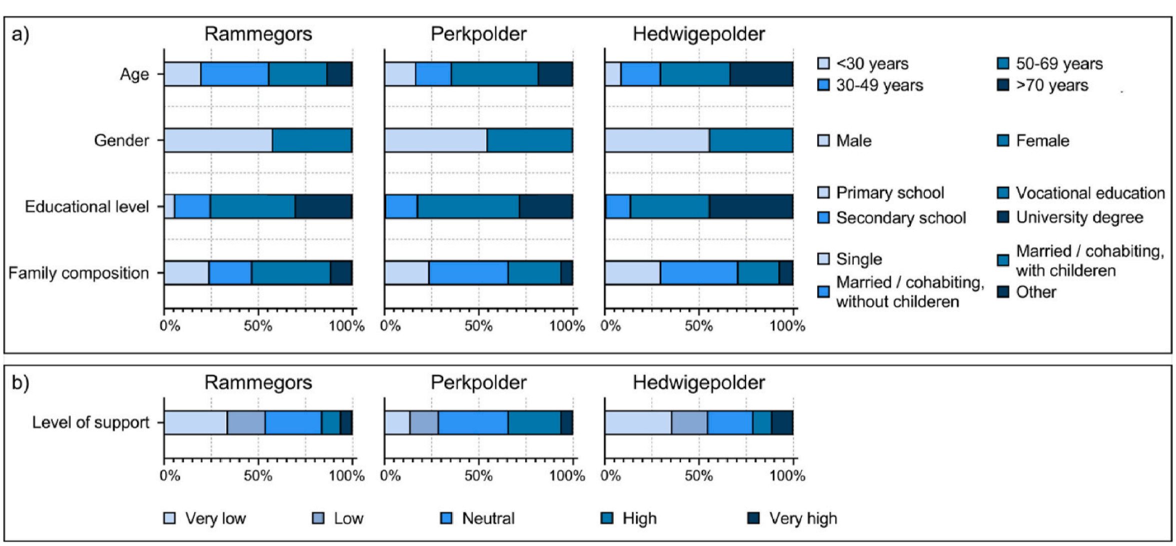

Fig. 2. Sociodemographic characteristics of the respondents (a) and their level of support for the landscape transformation (b).

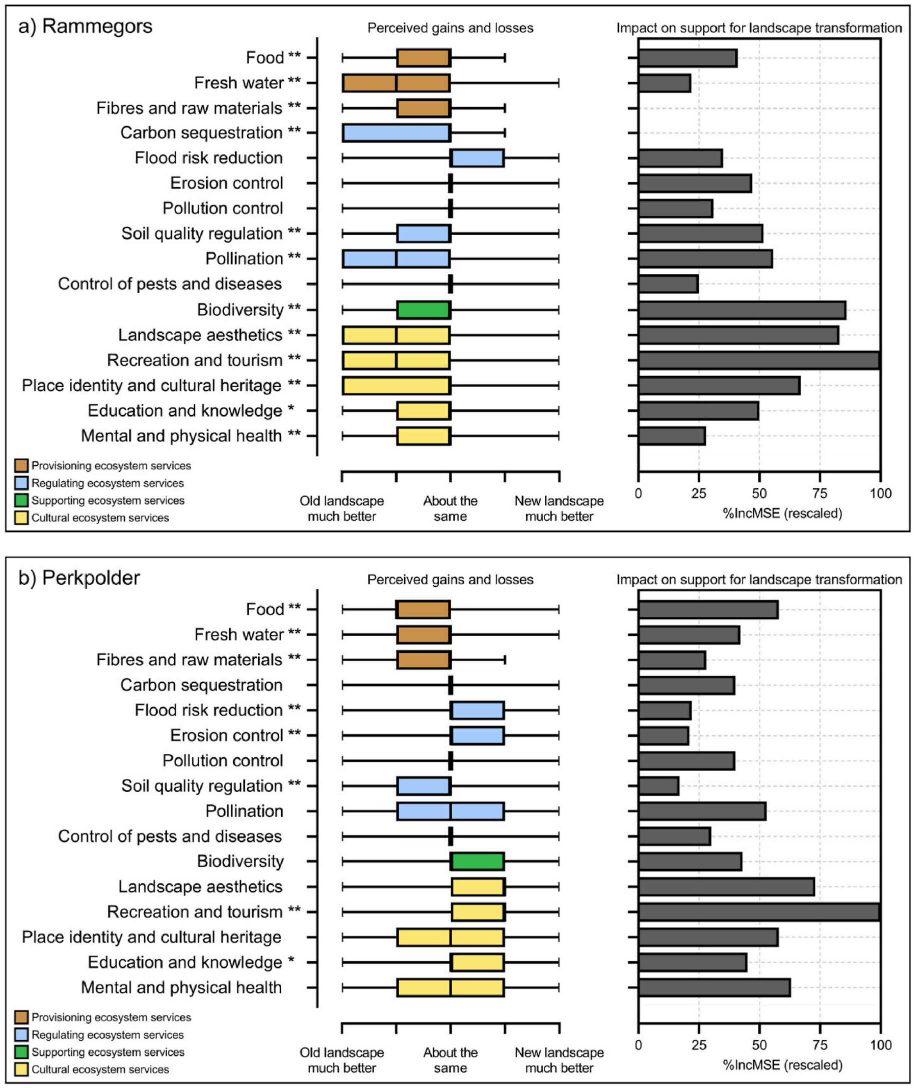

Fig. 3. Perceptions about changes in the availability of ecosystem services in Rammegors (a), Perkpolder (b) and Hedwigepolder (c), and impact of these perceived changes on the level of support for the landscape transformation. Left panel: The colored boxplots display provisioning ecosystem services in brown, regulating services in blue, supporting services in green and cultural services in yellow. Boxes inclining to the left of the middle point indicate that the availability of ecosystem services is generally perceived to be better in the old situation, while boxes toward the right indicate that the availability is perceived to be better in the new situation. Statistically significant differences between the availability of ecosystem services in the old and new situation are indicated with asterisks (* = $p < 0.05$; ** = $p < 0.01$). Right panel: The dark grey bar charts display the random forest regression results. Separate random forest models were specified for each of the three case study areas, with perceptions of the changed ecosystem services availability as the predictor variables and the level of support for the landscape transformation as the response variable. Bars indicate the relative importance of each predictor variable to model accuracy (measured as the percentage of increase in mean square error by permuting a predictor). (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

considered to decrease the availability of ecosystem services. In particular, the nearby population anticipates a negative impact on all provisioning ecosystem services as well as several regulating services (e.g. pollution control, pollination, and soil quality regulation) and cultural services (e.g. place identity and cultural heritage, as well as mental and physical health). Expected changes in the availability of these ecosystem services are statistically significant at the 0.01 or 0.05 level. In addition, the change in landscape attractiveness was found to be statistically significant at the 0.01 level, albeit the degree of variation in the perceived attractiveness between the old and new landscape shows that respondents anticipate both positive and negative aesthetic effects associated with the landscape transformation.

Expected changes in landscape aesthetics stand out as having the highest impact on the level of support for coastal realignment. The expected changes in the availability of all ecosystem services together explain 38.0% of the variance in the level of support for coastal realignment, see Table 2.

4. Discussion

It is widely accepted in policy and academia that intertidal ecosystems such as saltmarshes and tidal flats have a greater capacity to provide ecosystem services compared to polders (e.g. Costanza et al., 2014; Millennium Ecosystem Assessment, 2005), making coastal realignment an opportune management action to deliver benefits to society and increase human well-being. Previous studies have for instance highlighted how polder-saltmarsh transformations positively impact regulating services such as flood risk reduction and erosion control, as well as cultural services such as landscape attractiveness and opportunities for recreation and tourism (Luisetti et al., 2011; MacDonald et al., 2020).

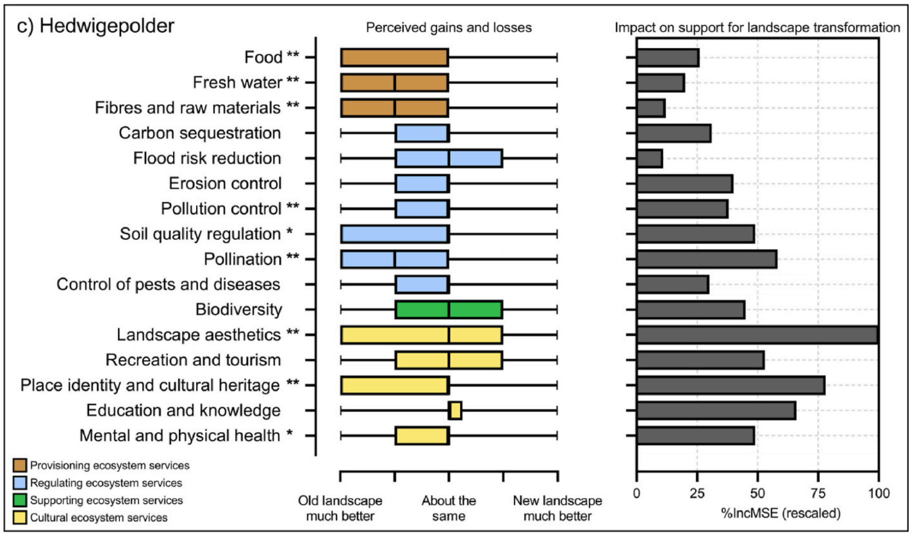

Fig. 3. (*continued*).

Table 2
Random forest regression model statistics.

	Mean of squared residuals	Variance explained (%)
Rammegors	1.03	31.5
Perkpolder	0.61	50.2
Hedwigepolder	1.13	38.0

Gains of regulating, supporting and cultural services have been reported to offset the loss of provisioning services associated with the conversion of the agricultural polder, such as crop production and fresh water supply (e.g. MacDonald et al., 2020). This allows coastal realignment interventions to achieve a net-increase in the availability of ecosystem services.

An important contribution of our study to the existing body of knowledge on coastal realignment is that local populations nearby project locations – in particular nearby the Rammegors and Hedwigepolder areas – more often than not consider the ecosystem services provided by the new (realigned) landscape to be less beneficial compared to the foregone ecosystem services associated with the conversion of the polder. This indicates that there is a discrepancy between how coastal realignment theoretically increases the availability of ecosystem services (i.e., what may be expected based on changes in ecosystem properties and functioning) and the extent to which the services of the new landscape are actually used and appreciated by local communities. The perceived loss of polder-related ecosystem services appears to outweigh the ecosystem services gains associated with the restoration of the intertidal area, which translates into a relatively low overall level of support for the landscape transformation.

Our study provides insight as to why the presumed benefits of coastal realignment are not fully recognized and valued by the local community. To begin with, the results show that in all three case study areas, the landscape transformation is perceived as having a negative impact on provisioning ecosystem services, including food, fresh water and fibres and raw materials. This was to be expected, in particular when it comes to the agricultural polders of the Perkpolder and Hedwigepolder areas – the conversion of which inevitably comes with impacts on agricultural production, fresh water supply and resources extraction (Gómez-Baggethun et al., 2019). In the case of the Rammegors area, the conversion from a freshwater wetland into a brackish nature reserve has reduced the availability of freshwater resources, while access restrictions imposed after the landscape transformation took place may have resulted in the loss of consumptive uses of the area. Our regression results indicate that in all three case study areas, the decline in provisioning ecosystem services has generally a low impact on the level of support for the landscape transformation. This suggests that the loss of the polder as a place for resources extraction and productive activities such as agriculture is not of major concern to the local population. Note that only a minor share of the respondents within our samples are employed in agriculture (on average about 4%), which may partly explain the low importance attached to polder-related provisioning ecosystem services.

Beyond impacts on provisioning ecosystem services, our results show that coastal realignment is often considered to decrease the availability of several regulating, supporting and cultural services. We found this to be most notable in the case of the Rammegors and Hedwigepolder areas. Many of the regulating services provided by intertidal ecosystems such as pollination, pollution control and carbon sequestration are not clearly visible – this in contrast to provisioning ecosystem services and cultural services such as landscape attractiveness. It is therefore reasonable to assume that local communities may not be fully aware of the regulating services provided by intertidal ecosystems (Scholte et al., 2016), nor appreciative of the contribution that coastal realignment could make to enhance these services. A lack of awareness and knowledge about regulating services may on the other hand explain why these services have a fairly limited impact on the level of support for the landscape transformation, as can be seen from our regression model outcomes. As suggested previously (Esteves, 2014; Goeldner-Gianella, 2007), raising awareness among the local community about the ecosystem services of intertidal areas could be part of the strategy to facilitate the implementation and wider uptake of coastal realignment interventions.

It is particularly interesting to see how coastal realignment affects perceptions about coastal protection and biodiversity, given that increasing the availability of these ecosystem services is usually a key policy argument underlying the implementation of projects (Brady and Boda, 2017; Ledoux et al., 2005). With respect to biodiversity, our results indicate that the transformation of Hedwigepolder and Perkpolder, from agricultural polder into intertidal ecosystem, is not associated with a statistically significant change in ecological value. Meanwhile, the local community nearby Rammegors considers the landscape transformation to have caused a significant impoverishment of biodiversity, which contrasts with the conception that coastal realignment contributes to ecological restoration (e.g. Esteves, 2014). In the specific case of Rammegors, recent ecological monitoring data show a notable increase in macrobenthic fauna, the presence of juvenile brackish-water fish and the colonization of saltmarsh-characteristic plant species such as Sea aster and Salicornia (Hamer et al., 2022), suggesting that the ecological value of Rammegors is increasing steadily since the area has been reconnected with the Eastern Scheldt. However, the area is still in transition from a freshwater wetland into an estuarine intertidal area and much of the native freshwater plant and animal species are gradually disappearing. This, in turn, could explain the lack of public support for the landscape transformation from a biodiversity standpoint, as also shown by our regression results. Given that estuarine biodiversity is generally appreciated by the public (Hutchison et al., 2015; McKinley et al., 2020), it could be expected that the biodiversity value of Rammegors will become increasingly recognized as the area further matures into an intertidal mudflat and saltmarsh landscape.

With respect to coastal protection, the removal or relocation of the primary sea defence as part of the landscape transformation has been reported in previous studies to increase the perceived risk of flooding, especially in flood-prone areas (de la Vega-Leinert et al., 2018). This could explain why coastal communities rate the flood protection capacity of the embanked polder to be higher than the restored intertidal ecosystem (see e.g. Goeldner-Gianella et al., 2015). Our results seem to be more nuanced, insofar that in two of our case study locations (Rammegors and Hedwigepolder), we found no statistically significant change in the perception of coastal protection induced by the landscape transformation. In the Netherlands, the risk of flooding is generally perceived to be low (Baan and Klijn, 2004; Terpstra, 2011), which may be a reason why public views about a change in coastal protection strategy are less pronounced compared to areas where flood risks are higher. In line with this, our regression analyses identified erosion control and flood risk protection to be factors whose impact on the level of support for the landscape transformation is generally low, suggesting that the possibility of flooding is not a primary concern of communities nearby coastal realignment project areas. Noteworthy, in contrast to Rammegors and Hedwigepolder, we found that the population nearby Perkpolder considers the realigned landscape to offer better coastal protection than the formerly agricultural polder. The new landscape provides greater visibility of the flood protective capacity of Perkpolder – most notably through the introduction of the newly established dike and the extensive intertidal area in front of the dike – which could be expected to increase the sense of flood safety among the public (Terpstra, 2011).

As already touched upon above, coastal realignment policies particularly aim at enhancing regulating and supporting ecosystem services, including coastal protection and biodiversity. Yet, our study shows that local communities in the Southwest delta generally attach limited value to these ecosystem services. Water safety is generally taken for granted, and there is often limited recognition for the significance of estuarine nature restoration. This implies that coastal realignment interventions, which are merely beneficial from a coastal protection and biodiversity point of view, are unlikely to raise much enthusiasm among the local communities. Hence, to improve social outcomes, it will be essential to design and implement interventions which – in addition to achieving the broader objectives of coastal protection and nature restoration – facilitate location-specific benefits that are deemed to be more important by the nearby community.

Our study sheds light upon what aspects could provide added value to local communities and deserve more attention in the design and implementation of future coastal realignment interventions. Most striking is that out of all ecosystem services considered, the perceived gains and losses of cultural services stand out as having the highest impact on the level of public support. In the case of Rammegors and Hedwigepolder, the landscape transformation is associated with the loss of cultural services such as opportunities for recreation and tourism, landscape attractiveness, and place identity and cultural heritage. This is in line with findings from previous studies, showing that these kinds of cultural ecosystem services of polder landscapes are generally rated higher than those of forelands (e.g. Chen et al., 2020). The loss of cultural ecosystem services largely shapes the negative attitudes toward coastal realignment within the Rammegors and Hedwigepolder areas, as shown by our regression results. A key challenge from a policy perspective will thus be to minimize these losses in future interventions, or better yet, look for opportunities to enhance cultural ecosystem services through coastal realignment.

In this regard, the Perkpolder case study reported here could provide for some relevant insights. The transformation of Perkpolder was not a stand-alone intervention but part of a broader spatial development initiative to give the area a boost. This was in response to the discontinuation of the local ferry service in 2003, which created momentum to redevelop and repurpose the Perkpolder area more broadly. One specific aim of the Perkpolder redevelopment plan was to integrate nature development while also creating opportunities for recreation and tourism. Our results point out that the improvement of the aesthetics and recreational quality of the area has been highly contributive to creating support for the landscape transformation. In particular, the newly established nature reserve has become an attractive location for local visitors and tourists from elsewhere. The reserve has been made accessible to the public via footpaths and cycling paths on top of the new sea dike, allowing visitors to clearly view and appreciate the estuarine flora and fauna within the reserve. In addition to the reserve, the redevelopment of Perkpolder has given rise to a beach club, a tour boat service in the summer season and an upgrade of the local beach area, while forthcoming developments include a marina with a capacity of 350 recreational boats and about 250 (vacation) houses. These investments in the area appear to offset in the perception of the local community the loss of the agricultural polders and polder-related ecosystem services, leading to an overall positive attitude to the coastal realignment intervention.

Given that our results may be used to inform coastal landscape management and decision making, it is important to reflect on our research methodology and explore possible limitations. First, the results and conclusions presented here are based on three separate case studies, each of which included a modest number of study participants (Rammegors $n = 83$, Perkpolder $n = 95$ and Hedwigepolder $n = 83$). This may have introduced sampling bias, meaning that the samples might not accurately reflect the target population. Nevertheless, the results obtained across the three case study locations were very similar, which suggests that the outcomes and main conclusions of our study are generalizable to a broader population – potentially to other villages nearby coastal realignment project locations elsewhere in the Southwest delta. Furthermore, a comparison of demographic characteristics of the respondents with census data of the study villages show small differences (CBS (2022), see appendix), which provides another indication that our sample is representative of a larger population. Second, we used a cross-sectional study design to examine perceptions about how the availability of ecosystem services has changed (Rammegors and Perkpolder) or will change in the future (Hedwigepolder) due to coastal realignment. It is important to emphasize that our results reflect feelings and perceptions of respondents in the current situation, showing, for instance, how they associate ongoing or former coastal realignment projects with the loss of ecosystem services. While it may be the case that respondents have inaccurate memories about the past, changed their opinion in the meantime or have false expectations about the future, that does not matter to the feelings or perceptions they have at present. To better understand perceptual changes over time, a longitudinal study is currently underway, in which we measure and compare perceptions about the transformation of the Hedwigepolder at different stages of the implementation process (i.e. before, during and after the intervention). As part of this study, we will also evaluate how perceptions of coastal realignment are shaped by a range of other variables, including place attachment, risk perception, social norms, and trust in authorities.

5. Conclusions

The restoration of intertidal ecosystems through coastal realignment has the potential to increase the availability of ecosystem services and contribute to human well-being. An important finding of our study is that communities living in the direct vicinity of project locations often attach limited value to the goods and services provided by intertidal ecosystems. Even widely accepted benefits of coastal realignment such as coastal protection and biodiversity restoration are often poorly recognized or appreciated. On the contrary, we found that local communities generally consider the ecosystem services provided by the realigned landscape to be less beneficial compared to the services provided by the landscape in the situation prior to its transformation. This indicates that coastal realignment is associated with losses rather than gains in ecosystem services, and brings to light a mismatch between how coastal realignment is viewed from a policy maker and local community perspective.

Our study shows at the same time how perceived gains and losses of ecosystem services enhance or diminish public support for coastal realignment. Of the four ecosystem services categories considered, we found that perceptions around the availability of cultural services – in particular around landscape attractiveness and opportunities for recreation and tourism – were most important in explaining the level of support for coastal realignment. In contrast, the gains and losses of provisioning, regulating and supporting services were generally not of major concern to the local community. This calls for a redefinition of the goals and priorities of coastal realignment to come to interventions which allow for a better balance between regulating, supporting and cultural services. Coastal protection and biodiversity objectives will remain central to coastal realignment, but future interventions will have to pay more attention to implications in terms of landscape attractiveness and recreational quality to enhance public support and achieve more socially acceptable and sustainable outcomes.

CRediT authorship contribution statement

Vincent Bax: Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing, Supervision. **Wietse I. van de Lageweg:** Conceptualization, Methodology, Resources, Writing – original draft, Writing – review & editing, Supervision, Project administration, Funding acquisition. **Teun Terpstra:** Conceptualization, Methodology, Formal analysis, Resources, Writing – original draft, Supervision, Project administration, Funding acquisition. **Jean-Marie Buijs:** Conceptualization, Methodology, Resources, Writing – original draft, Writing – review & editing, Supervision, Project administration, Funding acquisition. **Koen de Reus:** Methodology, Writing – original draft. **Femke de Groot:** Methodology, Writing – original draft. **Robin van Schaik:** Methodology, Writing – original draft. **Merhawi Arefaine Habte:** Methodology, Writing – original draft. **Joppe Schram:** Methodology, Writing – original draft. **Tom Hoogenboom:** Methodology, Writing – original draft.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Acknowledgements

This study was financially supported by Rijkswaterstaat (projects 20.43.001A and 20.43.002A) and Regieorgaan SIA Applied Research of the Dutch Research Council NWO (project "Living Labs in the Dutch Delta Hedwige-Prosperpolder").

References

Agyeman, J., Devine-Wright, P., Prange, J., 2009. Close to the edge, down by the river? Joining up managed retreat and place attachment in a climate changed world. Environ. Plann. 41, 509–513.
Baan, P.J., Klijn, F., 2004. Flood risk perception and implications for flood risk management in The Netherlands. Int. J. River Basin Manag. 2, 113–122.
Barbier, E.B., 2012. Progress and challenges in valuing coastal and marine ecosystem services. Rev. Environ. Econ. Pol. 6, 1–19.
Bax, V., van de Lageweg, W.I., van den Berg, B., Hoosemans, R., Terpstra, T., 2022. Will it float? Exploring the social feasibility of floating solar energy infrastructure in The Netherlands. Energy Res. Social Sci. 89, 102569.
Brady, A., Boda, C., 2017. How do we know if managed realignment for coastal habitat compensation is successful? Insights from the implementation of the EU Birds and Habitats Directive in England. Ocean Coast Manag. 143, 164–174.
Breiman, L., 2001. Random forests. Mach. Learn. 45, 5–32.
Brunetta, R., de Paiva, J.S., Ciavola, P., 2019. Morphological evolution of an intertidal area following a set-back scheme: a case study from the Perkpolder Basin (Netherlands). Front. Earth Sci. 7, 228.
Burden, A., Garbutt, R., Evans, C., Jones, D., Cooper, D., 2013. Carbon sequestration and biogeochemical cycling in a saltmarsh subject to coastal managed realignment. Estuar. Coast Shelf Sci. 120, 12–20.
CBS, 2022. Regionale Kerncijfers Nederland. Centraal Bureau voor de Statistiek. https://opendata.cbs.nl/. (Accessed 20 February 2023).
Chen, Y., Caesemaecker, C., Rahman, H.T., Sherren, K., 2020. Comparing cultural ecosystem service delivery in dykelands and marshes using Instagram: a case of the Cornwallis (Jijuktu'kwejk) River, Nova Scotia, Canada. Ocean Coast Manag. 193, 105254.
Costanza, R., De Groot, R., Sutton, P., Van der Ploeg, S., Anderson, S.J., Kubiszewski, I., Farber, S., Turner, R.K., 2014. Changes in the global value of ecosystem services. Global Environ. Change 26, 152–158.
de la Vega-Leinert, A.C., Stoll-Kleemann, S., Wegener, E., 2018. Managed realignment (MR) along the Eastern German Baltic Sea: a catalyst for conflict or for a coastal zone management consensus. J. Coast Res. 34, 586–601.
De Vet, P., Van Prooijen, B., Schrijvershof, R., Van der Werf, J., Ysebaert, T., Schrijver, M., Wang, Z., 2018. The importance of combined tidal and meteorological forces for the flow and sediment transport on intertidal shoals. J. Geophys. Res.: Earth Surf. 123, 2464–2480.
de Vet, P., van Prooijen, B., Wang, Z., 2017. The differences in morphological development between the intertidal flats of the Eastern and Western Scheldt. Geomorphology 281, 31–42.
Deegan, L.A., Johnson, D.S., Warren, R.S., Peterson, B.J., Fleeger, J.W., Fagherazzi, S., Wollheim, W.M., 2012. Coastal eutrophication as a driver of salt marsh loss. Nature 490, 388–392.
Doody, J.P., 2013. Coastal squeeze and managed realignment in southeast England, does it tell us anything about the future? Ocean Coast Manag. 79, 34–41.
Esteves, L.S., 2014. Current Perceptions about Managed Realignment, Managed Realignment: A Viable Long-Term Coastal Management Strategy? Springer, pp. 109–123.
French, P.W., 2006. Managed realignment–the developing story of a comparatively new approach to soft engineering. Estuar. Coast Shelf Sci. 67, 409–423.
Goeldner-Gianella, L., 2007. Perceptions and attitudes toward de-polderisation in Europe: a comparison of five opinion surveys in France and the UK. J. Coast Res. 23, 1218–1230.
Goeldner-Gianella, L., Bertrand, F., Oiry, A., Grancher, D., 2015. Depolderisation policy against coastal flooding and social acceptability on the French Atlantic coast: the case of the Arcachon Bay. Ocean Coast Manag. 116, 98–107.
Gómez-Baggethun, E., Tudor, M., Doroftei, M., Covaliov, S., Năstase, A., Onără, D.-F., Mierlă, M., Marinov, M., Doroșencu, A.-C., Lupu, G., 2019. Changes in ecosystem services from wetland loss and restoration: an ecosystem assessment of the Danube Delta (1960–2010). Ecosyst. Serv. 39, 100965.
Guerry, A., Silver, J., Beagle, J., Wyatt, K., Arkema, K., Lowe, J., Hamel, P., Griffin, R., Wolny, S., Plane, E., 2022. Protection and restoration of coastal habitats yield multiple benefits for urban residents as sea levels rise. npj Urban Sustain. 2, 1–12.
Hamer, A., Walles, B., van Belzen, J., Bouma, T., de Louw, P., van Dalen, J., Bax, V., van de Lageweg, W., 2022. Progress Report: Rammegors Tidal Restoration: Phase 2. Wageningen Marine Research.
Huguet, J.-R., Bertin, X., Arnaud, G., 2018. Managed realignment to mitigate storm-induced flooding: a case study in La Faute-sur-mer, France. Coast. Eng. 134, 168–176.
Hutchison, L., Montagna, P., Yoskowitz, D., Scholz, D., Tunnell, J., 2015. Stakeholder perceptions of coastal habitat ecosystem services. Estuar. Coast 38, 67–80.
Kelley, K., Clark, B., Brown, V., Sitzia, J., 2003. Good practice in the conduct and reporting of survey research. Int. J. Qual. Health Care 15, 261–266.
Kennish, M.J., 2002. Environmental threats and environmental future of estuaries. Environ. Conserv. 29, 78–107.
Ledoux, L., Cornell, S., O'Riordan, T., Harvey, R., Banyard, L., 2005. Towards sustainable flood and coastal management: identifying drivers of, and obstacles to, managed realignment. Land Use Pol. 22, 129–144.
Levi, S., 2021. Why hate carbon taxes? machine learning evidence on the roles of personal responsibility, trust, revenue recycling, and other factors across 23 european countries. Energy Res. Social Sci. 73, 101883.
Liaw, A., Wiener, M., 2002. Classification and regression by randomForest. R. News 2, 18–22.

Liski, A.H., Ambros, P., Metzger, M.J., Nicholas, K.A., Wilson, A., Krause, T., 2019. Governance and stakeholder perspectives of managed re-alignment: adapting to sea level rise in the Inner Forth estuary, Scotland. Reg. Environ. Change 19, 2231–2243.
Luisetti, T., Turner, R.K., Bateman, I.J., Morse-Jones, S., Adams, C., Fonseca, L., 2011. Coastal and marine ecosystem services valuation for policy and management: managed realignment case studies in England. Ocean Coast Manag. 54, 212–224.
MacDonald, M.A., de Ruyck, C., Field, R.H., Bedford, A., Bradbury, R.B., 2020. Benefits of coastal managed realignment for society: evidence from ecosystem service assessments in two UK regions. Estuar. Coast Shelf Sci. 244, 105609.
McKinley, E., Pages, J.F., Ballinger, R.C., Beaumont, N., 2020. Forgotten landscapes: public attitudes and perceptions of coastal saltmarshes. Ocean Coast Manag. 187, 105117.
Millennium Ecosystem Assessment, 2005. Ecosystems and Human Well-Being: Current State and Trends (Island, Washington DC. Island press, Washington, DC, 2005.
Murray, N.J., Phinn, S.R., DeWitt, M., Ferrari, R., Johnston, R., Lyons, M.B., Clinton, N., Thau, D., Fuller, R.A., 2019. The global distribution and trajectory of tidal flats. Nature 565, 222–225.
Myatt, L., Scrimshaw, M., Lester, J., 2003. Public perceptions and attitudes towards a forthcoming managed realignment scheme: freiston Shore, Lincolnshire, UK. Ocean Coast Manag. 46, 565–582.
Petillon, J., Potier, S., Carpentier, A., Garbutt, A., 2014. Evaluating the success of managed realignment for the restoration of salt marshes: lessons from invertebrate communities. Ecol. Eng. 69, 70–75.
Pontee, N., 2013. Defining coastal squeeze: a discussion. Ocean Coast Manag. 84, 204–207.
Roca, E., Villares, M., 2012. Public perceptions of managed realignment strategies: the case study of the Ebro Delta in the Mediterranean basin. Ocean Coast Manag. 60, 38–47.
Rotman, R., Naylor, L., McDonnell, R., MacNiocaill, C., 2008. Sediment transport on the Freiston Shore managed realignment site: an investigation using environmental magnetism. Geomorphology 100, 241–255.
Rulleau, B., Rey-Valette, H., Clément, V., 2017. Impact of justice and solidarity variables on the acceptability of managed realignment. Clim. Pol. 17, 361–377.
Scholte, S.S., Todorova, M., Van Teeffelen, A.J., Verburg, P.H., 2016. Public support for wetland restoration: what is the link with ecosystem service values? Wetlands 36, 467–481.
Sherren, K., Ellis, K., Guimond, J.A., Kurylyk, B., LeRoux, N., Lundholm, J., Mallory, M. L., Van Proosdij, D., Walker, A.K., Bowron, T.M., 2021. Understanding multifunctional Bay of Fundy dykelands and tidal wetlands using ecosystem services—a baseline. Facets 6, 1446–1473.
Sherren, K., Loik, L., Debner, J.A., 2016. Climate adaptation in 'new world' cultural landscapes: the case of Bay of Fundy agricultural dykelands (Nova Scotia, Canada). Land Use Pol. 51, 267–280.
Smaal, A., Nienhuis, P., 1992. The Eastern Scheldt (The Netherlands), from an estuary to a tidal bay: a review of responses at the ecosystem level. Neth. J. Sea Res. 30, 161–173.
Steele, J., Bourke, L., Luloff, A., Liao, P.-S., Theodori, G.L., Krannich, R.S., 2001. The drop-off/pick-up method for household survey research. Community Dev. 32, 238–250.
Terpstra, T., 2011. Emotions, trust, and perceived risk: affective and cognitive routes to flood preparedness behavior. Risk Anal.: Int. J. 31, 1658–1675.
Turner, R.K., Burgess, D., Hadley, D., Coombes, E., Jackson, N., 2007. A cost–benefit appraisal of coastal managed realignment policy. Global Environ. Change 17, 397–407.
van Buuren, A., Nooteboom, S., Teisman, G., 2012. Climate adaptation in complex governance systems: governance systems between inertia and adaptability. In: de Roo, G., Hillier, J., van Wezemael, J. (Eds.), Complexity and Planning: Systems, Assemblages and Simulations (New Directions in Planning Theory). Ashgate Publishing, London, pp. 221–242.
van der Ham, W., 2009. Hollandse Polders. Boom, Amsterdam.
Van der Werf, J., De Vet, P., Boersema, M., Bouma, T., Nolte, A., Schrijvershof, R., Soissons, L., Stronkhorst, J., Van Zanten, E., Ysebaert, T., 2019. An integral approach to design the Roggenplaat intertidal shoal nourishment. Ocean Coast Manag. 172, 30–40.
Warner, J.F., van Staveren, M.F., van Tatenhove, J., 2018. Cutting dikes, cutting ties? Reintroducing flood dynamics in coastal polders in Bangladesh and The Netherlands. Int. J. Disaster Risk Reduc. 32, 106–112.
Zhao, Q., Chen, Y., Gone, K.P., Wells, E., Margeson, K., Sherren, K., 2023. Modelling cultural ecosystem services in agricultural dykelands and tidal wetlands to inform coastal infrastructure decisions: a social media data approach. Mar. Pol. 150, 105533.