Examining just and resilient adaptation in light of the Bacton-Walcott sandscaping scheme

Public information board on the sandscaping scheme overlooking Bacton beach and Bacton Gas Terminal, North Norfolk, Autumn 2022 (Photo: I Cotton)

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Abstract

England's coastline is highly vulnerable to coastal erosion, and an increasing number of settlements will be at risk as this century progresses. However, the country is underprepared for adapting to long-term coastal change (CCC, 2023). In 2019, the UK's first large-scale sandscaping project was completed on the North Norfolk coast to protect the nationally important Bacton Gas Terminal and nearby villages. While existing research has examined the direct environmental and social impacts of sandscaping, this study addresses a research gap on the broader implications of sandscaping for preparing for long-term coastal change. As a potentially transformative coastal strategy, this research uses an environmental justice lens to examine transformation and resilience, given scale-sensitivities and issues of equity attributed to resilient approaches.

An interdisciplinary, mixed methods approach is adopted to investigate local resident and policymaker perspectives of sandscaping and wider coastal change, using a survey and semi-structured interviews, combined with analysis of geomorphological change. Results reveal that sandscaping has physically transformed the coastal system, by dramatically increasing beach volume and width. Views on the effectiveness of sandscaping amongst local residents are wide-ranging, and coastal adaptation is disputed where it threatens the integrity of settlements, and if unaccompanied with sufficient practical and financial support. Residents have an increased sense of security of future coastal change through the protection afforded by sandscaping, but there is a risk of maladaptation if reduced concern of erosion risk in the future affects willingness to engage in coastal adaptation in the present.

Overall, the research demonstrates incorporating justice principles into coastal adaptation planning is fundamental for successful community engagement, both to overcome historic environmental justice issues and to facilitate community willingness to adapt. Through its interdisciplinary approach, this thesis also reveals that evaluations of nature-based solutions like sandscaping should go beyond geomorphological analysis, to also consider social dimensions.

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List of Acronyms

ACM – Anglian Coastal Monitoring (Programme)

AOD - Aerial Optical Depth

CCC – Committee on Climate Change

CCAG – Coastal Concern Action Group

CCS – Carbon Capture and Storage

CLIFF – Coastal Loss Innovative Funding and Finance

CTAP – Coastal Transition Accelerator Programme

Defra – Department for Environment, Food and Rural Affairs

DLUHC – Department for Levelling Up, Housing and Communities

EA – Environment Agency

EEA – European Environment Agency

FCERM – Flood and Coastal Erosion Risk Management

GDPR – General Data Protection Regulations

IFCA – Inshore Fisheries and Conservation Authority

IPCC – Intergovernmental Panel on Climate Change

LiDAR – Light Detection And Ranging

MMO – Marine Management Organisation

NNDC – North Norfolk District Council

NSTA – North Sea Transition Authority

RH – Royal HaskoningDHV

SMP – Shoreline Management Plan

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Introduction

This first chapter introduces the reader to the key themes of the research, and highlights the importance of the research topic. This is solely as a top-level overview to the study, with Chapters two, three, and four providing more in-depth context to the relevant policy and case study background, academic literature and methodology, respectively. This chapter ends with an outline of the research questions and the remaining chapters of the thesis.

1.1 Managing coastal change in a climate warming world – is transformational adaptation required?

England's coastal communities face increasingly urgent environmental pressures in the 21st century (Committee on Climate Change, CCC, 2018). Coastal flooding and erosion affect over 500,000 properties a year, and cause annual damages of over £250 million (CCC, 2018). Such figures do not account for non-monetary loss such as mental and physical health impacts or disruption to local place for communities (Day, 2020). Further, if one considers the economic impact of loss of ecosystem services, damage to coastal environments costs the UK billions every year (and £15 billion, annually, by 2050) (Johnson et al., 2020a). During extreme weather events, coastal areas may also experience secondary impacts for a continued period after, such as power shortages, closed transport networks, and disrupted public or community services (CCC, 2018). Whilst certain regions are at higher risk, coastal change is a national issue, with the majority of England's coastal counties containing areas vulnerable to coastal flooding or erosion (Sayers et al., 2017).

Disconcertingly, impacts from coastal change are projected to become far more severe as the 21st century progresses. The extent of this severity depends in part on the degree to which global mitigation targets, of curtailing global warming to 2ºC, are met, of which there remains considerable uncertainty. The UK has experienced consistent sea level rise in recent decades (Woodworth et al., 2009), and the observed 16.5cm increase since 1901 (Kendon et al., 2021) could, under 4ºC global warming, rise to 1.12m by 2100 (Haigh et al., 2022). Whilst coastal erosion is a natural process that has always occurred, sea level rise, and more intense and frequent storms, are causing more extensive and accelerated erosion rates (Edwards, 2017). Sea level rise and storms expose coasts to greater wave height (Wong et al., 2014). This means there is a lower threshold with which storm surges will lead to flooding or erosion (Haigh et al., 2022). The UK is therefore likely to experience both more flooding and erosion, but also more severe flooding and erosion. Even if the Paris agreement is upheld and warming is contained to 2ºC above pre-industrial levels, delay in the climate system entails that the UK will continue to experience sea level rise and extreme weather events far into the 21st century (CCC, 2018).

The number of properties at risk of flooding in England is expected to rise three-fold, from 520,000 in present-day to 1.5 million by 2080 (CCC, 2018). For coastal erosion, there is a ten-fold increase in properties susceptible (residential and non-residential), from 8,900 today to 100,000 by 2080 (CCC, 2018). These upper-estimate projections, based on past erosion rates, are under a ‘no active intervention’ scenario of no further coastal defences, but do not account for future climate change accelerated risk (Jacobs, 2018). In comparison, analysis by Sayers et al., (2022) reveals that under high warming scenarios (2-4ºC), it may no longer be economically viable to continue a ‘hold the line’ policy (i.e. continue with coastal defences) for nearly a third of England’s coastline (affecting 160,000 properties). Therefore, the true scale of coastal properties at risk of erosion this century may yet to be realised, and there may be significant political decisions and pressure to change current coastal policy in some coastal areas. Although adaptation to coastal change has always taken place to some degree, it is the accelerated risk and scale of change, exacerbated by climate change, that is so challenging. And whilst coastal flooding affects more properties, the permanence of coastal erosion and the rapidly accelerating risk entail it is ranked as one of the most pressing climate impacts facing England and the rest of the UK (CCC, 2017), and therefore how we adapt to such rising risk requires urgent attention. Given the seriousness of this risk, there are increasing calls within academic literature and global climate policy for 'transformational adaptation' to coastal change, where it may not be possible to retain all coastal settlements and some relocation is required.

Amidst scientific uncertainty of coastal risk, it is also currently unclear as to how the UK government will respond to the increasing risk of coastal change. The CCC, the government's independent advisory body on climate adaptation, assessed England as underprepared in dealing with coastal change, with adaptation measures currently insufficient to address the projected impacts this century, according to the CCC[1]'s (2018) landmark assessment on preparedness to coastal change. A more recent assessment by the CCC (2023) continues to evaluate 'mixed progress' on adaptation in England to coastal erosion risk. As Chapter 2 will explore, there is currently a lack of policy guidance on adaptation to long-term coastal risk.

[1] The Climate Change Committee is the independent body advising the government on climate change adaptation and mitigation policy.

1.2 The rise of the 'resilience' narrative

The conceptualisation of adapting to climate change is becoming increasingly intertwined with the idea of 'resilience'. This can be seen at a global level, where the Intergovernmental Panel on Climate Change (IPCC) equates the objective of adaptation as one of increasing resilience (IPCC, 2022). Chapter 3 will explore how resilience can be defined and operationalised, but in essence resilience is about increasing one's capacity to withstand the impacts of a change (Folke et al., 2005). There is policy attention to resilience in numerous areas, not solely climate or coastal management policy: the built environment, mental and physical health, and disaster response sectors all use a framing of resilience (Matyas and Pelling, 2015).

Applying the concept of resilience in a climate or coastal policy context is challenging, because the concept is (amongst other aspects) dynamic, plural, and context-specific (Cutter, 2016; Bene and Doyen, 2018). The widespread use of the concept, in an ambiguous and subjective manner, is also a prominent criticism (Cutter, 2016). Coastal environments are made up of numerous components and feedbacks (species, ecosystems, social groups, networks and institutions), each of which will respond in different ways and on different timescales to a shock or intervention (Virapongse et al., 2016; Maclean et al., 2016). Furthermore, others have argued that changes to resilience is not a singular event, and levels of resilience will vary over time (Matyas and Pelling, 2015; Bene and Doyen, 2018). Whilst the current Flood and Coastal Erosion Risk Management Strategy (hereafter FCERM) states it will take time to increase social and environmental resilience to coastal risks, there is little discussion of what these temporal dynamics mean in practice (Environment Agency, hereafter EA, 2020). While there is ample research on the concept of resilience, Fisher et al., (2018) argue that further work is needed that examines the complex nature of resilience in relation to time.

A key question raised by the previous section (1.1) is whether increasing coastal risk requires transformative coastal management solutions. As Chapter 3 will explore, different academic fields have broad agreement that transformation is a win-win strategy to build a high level of resilience within a system (e.g. Wong et al., 2014; Matyas and Pelling, 2015; Matin et al., 2018, Bene and Doyen, 2018; Milhorance et al., 2021). Furthermore, the IPCC's sixth assessment report (2022) on climate adaptation argues that a transformative approach has the ability to overcome the limits of other, less ambitious forms of adaptation, whilst also achieving other climate or societal goals. However, such assessments appear based on theoretical assumptions, with little research grounded in an empirical context (Brown, 2014). For example, does fundamental system change (i.e. transformation) always correspond to increased resilience? Could it lead to undesirable change (i.e. maladaptation)? Does whether transformation is forced or planned have a bearing on changes to resilience? These are key questions regarding transformation that will be explored through this research, using a case study of sandscaping on the Norfolk coast. Nature-based solutions are increasingly being used in climate adaptation (IPCC, 2022), and the use of novel nature-based solutions to increase resilience to coastal change is a clear example of where urgent climate risk and policy attention to resilience has led to calls for bigger, more innovative approaches. This research analyses the deployment of an innovative nature-based solution (sandscaping) in order to critically assess the concepts of resilience, transformation, and maladaptation.

1.3 What does 'just adaptation' to coastal change look like?

The limitations of pursuing resilience approaches to adaptation have been raised by Leach (2008) and Eakin et al., (2009), who argue they prioritise healthy functioning of ecosystems over potentially disproportionate impacts on some societal groups. In England, some coastal communities are no longer protected by coastal defences, and may have to move in response to increased coastal erosion and flood risk. A coastal management policy switch in 2005 from ‘hold the line’ to ‘managed realignment’ in some coastal areas is still disputed to this day, as Chapter 2 will detail as background context, and the empirical chapters (Chapters 6 and 7) will explore. While in England ‘resilience’ is the framing with which the risk of coastal change is managed, this is not the case in other countries. The most striking example is the Netherlands, where the entire coastline is protected, and risk is controlled rather than an attempt to solely reduce its effects (Kaufmann et al., 2018). The Norfolk coastal villages analysed in this case study have had a changing and contested history of managing coastal change (outlined in Chapter 2). Furthermore, different coastal villages within the case study area, despite sharing similar high risks of erosion, have different levels of protection depending on whether the use of public funds for coastal management schemes can be justified. If only areas with significant populations or infrastructural assets are defended, this raises questions of environmental justice, on where the impacts of coastal change are felt, and how the perspectives of local communities are incorporated into decision-making. Environmental justice is the key analytical lens used by this research to explore the implications of coastal management approaches focussed on building resilience.

1.4 Trade-offs in coastal management

As section 1.1. highlights, given the scale of the physical risk of coastal change that the UK will face this century, there will be difficult decisions in coastal management on where is and is not defended, for how long, and what outcomes are prioritised over others (Tompkins et al., 2008; Eakin et al., 2009). The different, and potentially conflicting choices in environmental decision-making can be described as 'trade-offs', which Foerster et al., 2015 (p.460) define as "*an explicit or implicit prioritisation of one set of values over another. Decisions about which values to prioritise involve complex temporal, spatial and sectoral dimensions*". There is ample work highlighting that adapting to climate impacts involves trade-offs, such as unintended social, ecological, or economic impacts (Chaigneau et al., 2018; Papadimitriou et al., 2019), knock-on effects for different sectors (Sharifi, 2020) or conflicts between adaptation and mitigation objectives (Sharifi, 2020). Trade-offs manifest not only in the present-day but across different timescales, with future generations likely to experience the more severe impacts of climate change (Meyer, 2017).

As section 1.2 highlights, adaptation strategies that utilise green infrastructure or nature-based solutions are increasingly being adopted for their range of co-benefits, but research has nonetheless highlighted trade-offs in their use (Choi et al., 2021; Loon-Steensma and Vellinga, 2013). Furthermore, the assumption that coastal management strategies designed to serve both social and environmental needs, such as Marine Protected Areas, also avoid negative impacts for people and the environment, is contested (Chaigneau and Brown, 2016). Given the diversity of actors and complexity of issues in coastal settings, understanding the range of impacts of a coastal strategy across scales appears highly relevant. In a UK context, inherent in the decision-making process are choices about what degree of coastal risk is acceptable for society to live with, and what level of finance and resources is deemed appropriate to managing the issue (Tompkins et al., 2008). Conflicts can arise in what outcomes are prioritised, and at what scale (Eakin et al., 2009). For example, Cooper and McKenna (2008) argue it is increasingly difficult to justify allocation of funding for local schemes in the UK, if the decision-making parameters are viewed at a national level, and on longer time horizons.

There are also different approaches to valuing coastal environments, which goes beyond monetary forms of value to consider aspects such as intrinsic, instrumental and relational values (Himes and Muraca, 2018). For example, tangible (e.g. built monuments) and intangible (e.g. sense of place) forms of cultural heritage are not easily monetizable forms of value that can nevertheless be considered by local communities as significant attributes of where they live. As Fortnam et al., (2023) highlights, the impacts of a particular coastal management strategy may not be immediately obvious, and require a just consultation process with relevant stakeholders to identify. These non-monetary, or plural, forms of value may not be considered in decision-making on the costs and benefits of a certain coastal management approach. Where and when coastal impacts materialise, experienced by whom, and where and when resilience is built, are key themes of this research.

1.5 Study aims and research questions

This thesis critically analyses a case study example of a transformative approach to managing and building resilience to coastal change in England – sandscaping, which was introduced on the Norfolk coast in 2019. This PhD uses an environmental justice lens to examine coastal change issues in the case study area, and the impacts of sandscaping. The aim is to critically unpack ideas of resilience, transformation, and maladaptation, by asking ‘transformation for who or what, how, and on what scales?’. Resilience could be explored in infinitely different ways or discrete sub units within a system. This PhD focuses on differences between social and geomorphological resilience, and social resilience for different villages with different coastal management contexts. It uses mixed methods of qualitative and quantitative approaches (survey, interviews, and analysis of geomorphological data) to explore social and geomorphological dimensions to coastal change in the case study area. Chapter 4 will outline the methodology in detail.

Chapters 6 and 7 in particular will explore how adaptation to coastal change can be facilitated, and the different perceptions of local residents and policymakers on adaptation under a managed realignment policy scenario. It is important to research the social perceptions of sandscaping and managing coastal change; 1) to identify any unintended side-effects of sandscaping, that can be mitigated in the roll-out of future schemes, 2) to provide learning on how the public can be brought on board and engaged with novel coastal management strategies in their area, and 3) to design just coastal management approaches that are socially acceptable to relevant stakeholders.

A key question lies in how sandscaping might influence perceptions on long-term coastal risk (i.e. beyond the lifetime of the scheme): will sandscaping be repeated, and what is this dependent on? The implementation of sandscaping therefore raises important questions around the longevity of settlements on this stretch of coast. As Chapter 2 will outline, there is existing research analysing the geomorphological and ecological impact of mega-nourishment approaches such as sandscaping, but minimal research on social dimensions; how sandscaping is perceived, its social impacts, and how it might influence perceptions of managing future coastal change, which this PhD focuses on.

Since the use of sandscaping in England (the Bacton-Walcott sandscaping scheme), large-scale projects have been completed elsewhere internationally, including in Shippagan, Canada, in 2020 (Graham et al., 2023), and in Togo and

Benin in April 2023 (Dredging Today, 2023). The Crown Estate have identified twenty-two other coastal areas in England where sandscaping could be replicated (Flikweert, 2017), and a feasibility study is currently being conducted for another sandscaping scheme in Norfolk, in Gorleston (Eastern Daily Press, 2022). As of yet, no further schemes have been approved in the UK. Therefore, this research provides empirical findings on the social and geomorphological impacts of sandscaping that can support the design and implementation of future schemes. Research that identifies co-benefits or unintended social impacts (e.g. whether sandscaping increases or decreases resilience to coastal change) may either make it easier to justify funding for future schemes, or inform future schemes on potential social or justice issues associated with sandscaping's implementation.

Aims and research questions

The first aim of this research is to investigate the impacts of sandscaping, based on the first 4 years of the Bacton-Walcott sandscaping scheme (i.e. this PhD gathers data from 2019-2022). In particular, it seeks to understand in what contexts sandscaping can be considered a transformational adaptation strategy (for both physical and social dimensions). Geomorphological analysis is undertaken to explore how the coastal system is responding to sandscaping. Covering different case study villages, including defended and undefended coastlines, the second aim of this thesis is to explore public perceptions of coastal change and coastal adaptation, from an environmental justice perspective. The social dimensions considered here are how local residents perceive and are impacted by the sandscaping scheme and coastal change, across time and space. Local residents' perspectives are compared to coastal policymakers, to identify areas of similar or contrasting views that have implications for coastal management policy. This is with a view to considering the third aim of this research, which is to provide insight on how resilience, equity, and justice can be combined in coastal adaptation policy.

To answer these aims, the following research questions have been designed:

1. **Has sandscaping transformed the physical resilience of the coastal system? Is the scheme working geomorphologically as expected, and what are the observed coastal changes in the first four years?**

a. How have beach profile and sediment volume budgets changed at Bacton and Walcott?

b. What are current rates of cliff retreat at Happisburgh?

c. Is there a significant difference in beach volume in the four years before and after sandscaping, and if so, where on the coastline is this the case?

2. **What are local residents' perceptions and experiences of coastal change, over different timescales, and how do these compare to coastal policymakers, and between villages of differing proximity to sandscaping and differing coastal management plans (e.g. defended or undefended)?**

a. What are the social impacts and perceptions of sandscaping amongst Bacton and Walcott residents? (Chapter 5)

b. For Happisburgh residents, what are the perceptions and lived experiences of past, present and future coastal change? (Chapter 6)

c. For Bacton and Walcott residents, how do perceptions of sandscaping affect willingness to adapt and perceptions of coastal change beyond the lifetime of the scheme (ca. 20 years in the future)? (Chapter 7)

3. **What are the implications of the above findings on incorporating environmental justice into coastal adaptation policy that focuses on building resilience?**

1.6 Thesis outline

This thesis is divided into nine chapters (eight subsequent to this introductory chapter). Chapter two provides background context for the research and introduces the case study. An overview is provided of coastal management policy, sandscaping, and the case study villages.

Chapter three contains the literature review, structured around the topics of resilience, environmental justice, and adaptation. Key concepts and research gaps from these topics are used to develop a conceptual framework, summarised at the end of the chapter.

Chapter four provides an overview of the methodology, as a mixed methods, interdisciplinary case study research project. The positionality of the researcher (an individual's many social identities that can be perceived by others; Folkes, 2022), and the ontological and epistemological perspective of the work, is reflected on, before outlining data collection and analysis. Ethical issues and methodological limitations are also explored.

Chapter five is the first results chapter, presenting local residents perceptions and geomorphological observations of the effectiveness of the sandscaping scheme. This chapter answers research question 2a, on the impacts of sandscaping and local resident perceptions on how the scheme has performed in the first few years, as well as future perceptions of sandscaping effectiveness. It also contributes to answering research question 1, where residents' perceptions are compared alongside an analysis of beach profile changes at Bacton and Walcott post-sandscaping.

Chapter six is the second results chapter, and presents empirical findings on the environmental justice issues put forward by residents in different coastal villages, of differing policy contexts, on managing coastal change. This includes Bacton and Walcott residents, on the implementation of the sandscaping scheme, and in answering research question 2b, on the lived experience of Happisburgh residents living alongside an undefended coastline. Residents' perceptions are considered alongside policymakers' perspectives, highlighting areas of agreement and disagreement. This analysis is supported by geomorphological analysis of cliff retreat at Happisburgh, which answers research question 1b.

Chapter seven is the third and final empirical chapter, presenting findings for research question 2c on Bacton and Walcott residents and policymaker perceptions of coastal management after the lifetime of the sandscaping scheme. Topics explored include the future of Bacton gas terminal, perceptions of coastal risk and of managed realignment. Social perspectives are presented alongside sediment volume calculations pre- and post- sandscaping from Bacton Gas Terminal to Happisburgh, tested for statistical significance, which forms the final element of the geomorphological analysis (research questions 1a and 1c).

The empirical chapters are succeeded by a discussion and synthesis chapter, which outlines the main theoretical and methodological contributions to the research, and potential modifications to the conceptual framework, from the cross-cutting themes emerging across the three empirical chapters. The chapter ends with a consideration of limitations and potential areas of future research.

The final chapter of the thesis (Chapter nine) is the conclusions chapter. It begins by summarising the key findings of each results chapter in relation to the research questions. Subsequent to this overview, research findings are summarised in relation to relevant insights for practitioners, policymakers, academics and other stakeholders.

2. Background context

2.1 Introduction

This chapter introduces the relevant policy background and local context for this thesis. An outline of the history and development of UK coastal management policy is presented first in section 2.2, and includes an overview of key policy actors and funding streams. The advantages and disadvantages of different strategies to managing coastal change, such as hard engineering and soft engineering, are summarised in section 2.3, with a particular focus given to beach nourishment and the Zandmotor scheme in the Netherlands, of which the sandscaping scheme was developed from. Lastly, this chapter introduces the case study area in section 2.4: the villages of Bacton, Walcott and Happisburgh. The history of coastal management in each of the villages is described, before an overview of the Bacton-Walcott sandscaping scheme.

2.2 Policy overview

2.2.1 History and evolution of coastal management

While much of the UK's coastal defences were originally built in the Victorian era (French, 2004), this section focuses on coastal management policies post-1945, given the significant policy changes at this time, for example the Coast Protection Act (1949), which remains pivotal legislation today. The following section is split into two epochs; 1945-2005 and 2005-present, to reflect the significant shift in approach following the Department for Environment, Food and Rural Affairs'

(Defra[2]) (2005) *Making Space For Water* strategy (outlined below). As UK coastal management is devolved, and implemented at a regional level, this section also focuses on policies relevant to England and the North Norfolk coast.

1945-2005: risk-based approach

Today's governance structure for coastal management was set with the passing of the Coast Protection Act (1949) after the Second World War. The Act (ibid) gave local coastal authorities (and risk management authorities) the powers and responsibility to implement coastal management works, where previously this responsibility lay with national government. A few years later in 1953, the UK experienced a devastating flood event that sparked deep conversations on coastal management (Frew, 2012). The 1953 floods resulted in loss of life and infrastructural damage across the country, and it became clear that indefinite coastal protection for the entire UK coastline would be challenging (Frew, 2012). Despite this, the roll-out of coastal defense schemes intensified, contributing to a perception amongst the wider population that the coastline could remain static and unchanging (Nicholls et al., 2013).

Coastal management plans for specific areas began to be developed in the 1980s, but the publication of Shoreline Management Plans (SMPs) in 1996 (EA, 1996) heralded the first coordinated approach to coastal management across different coastal areas in the UK (French, 2004). Despite being non-statutory (not legally binding), SMPs remain the principal policy document that underpins coastal management decision-making in England and Wales (POST, 2021). The plans provide a strategic overview of how different areas of England's coastline are to be managed, in a coordinated way, by setting short (0-20 years), medium (20-50

[2] The Department for Environment, Food and Rural Affairs (Defra) is the government department responsible for policy and strategy relating to flooding and coastal erosion, within its broad environment remit.

years) and long term (50-100 years) policy objectives (CCC, 2018). A second, revised version of SMPs was published in 2005, which was later updated in 2012 and 2019 with new policy information (Jacobs, 2019). Figure 2.1 illustrates the release of each SMP version alongside key strategy documents or Acts of Parliament relating to coastal management. There are four overarching policy designations within SMPs: ‘hold the line’, ‘advance the line’, ‘managed realignment’, and ‘no active intervention’ (POST, 2021). While being well-used, the plans have been criticised for not being statutory policy documents, or not accompanied with practical guidance (O’Riordan et al., 2014), funding or support (Vikolainen et al., 2017) to local authorities.

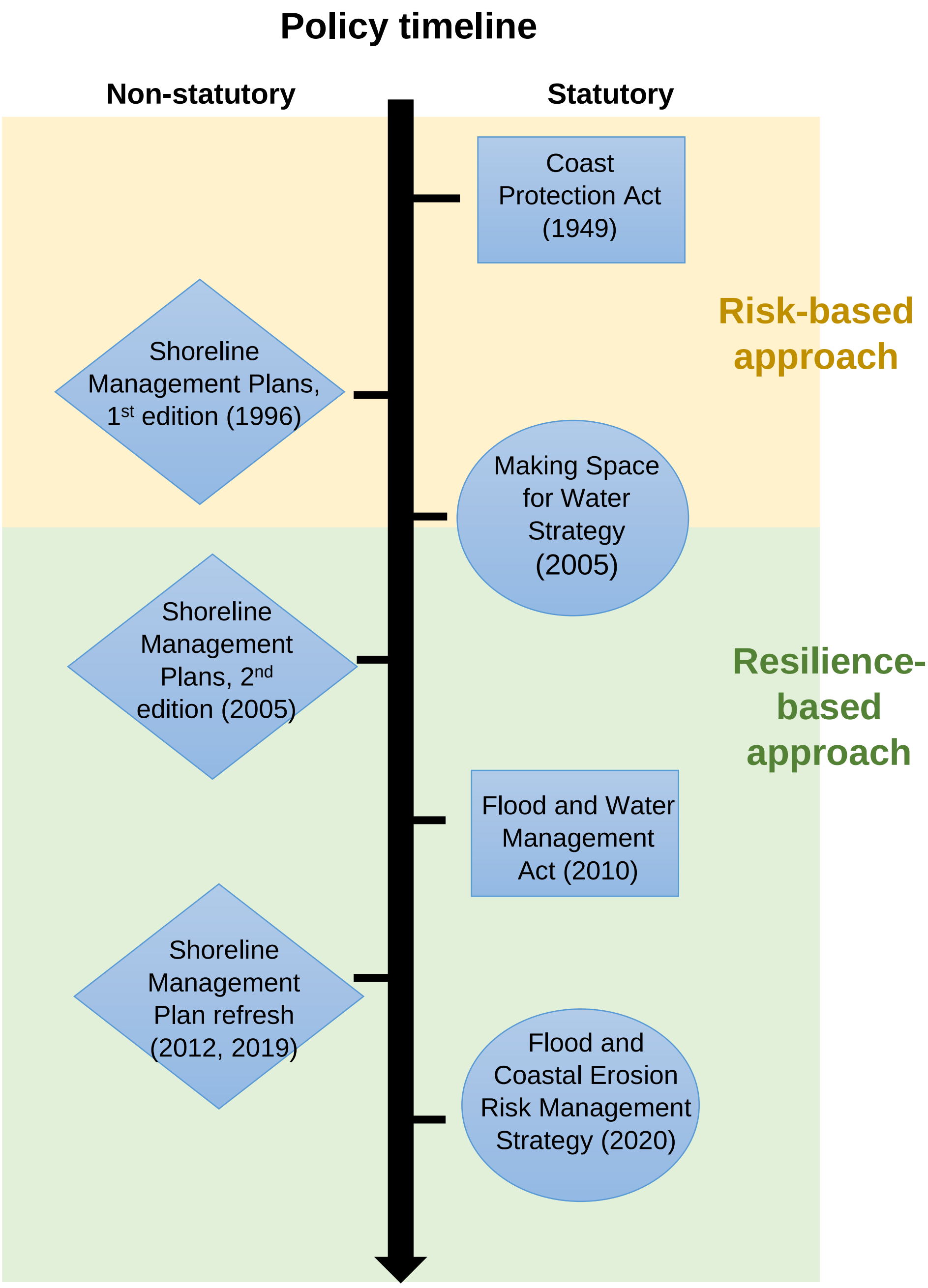


Figure 2.1 Timeline of key Acts of Parliament (rectangle), strategy documents (circle), and non-statutory shoreline management plans (diamond), alongside the overall evolution from a risk-based (yellow) to a resilience-based (green) approach in England. (Figure: I Cotton)

2005-Present: resilience-based approach

In 2005, the release of Defra's *Making Space for Water* strategy heralded a dramatic policy shift, by concluding that not all of England's coastline could be protected indefinitely from coastal erosion, as to do so would be economically unviable. There was also increasing evidence that hard defences were exacerbating erosion risk in adjacent areas to which they were implemented (discussed further in section 2.3.1 below). Due to this, many SMPs with a ‘hold the line’ policy were revised. This was hugely unpopular with many coastal communities, and there is longstanding disagreement in many coastal areas between residents and their local SMP designation (the response within this thesis’ case study villages are outlined in section 2.4.2). *Making Space for Water* was a significant policy change, because the strategy reflects a fundamentally different philosophy for managing coastal erosion risk. Where before the objective was to control risk, *Making Space for Water* conceded that the risk of coastal erosion could only be reduced. This had huge ramifications for coastal communities, used to a coastline that would forever be protected. Coastal protection is now only afforded to areas of significant strategic importance, infrastructure or assets, or availability of partnership funding. The implication is that some coastal areas subsequently face a risk of flooding and erosion where previously they may have been protected by coastal defences. Policymakers, Stallworthy (2006) argues, have deprioritised the risk of coastal erosion for certain communities since *Making Space for Water*, on the basis of ever increasing climate risk and cost. Social trade-offs, the author (ibid) argues, have been legitimised.

Consequently, policy documents after 2005 have adopted a resilience, rather than risk-based, approach to coastal management (Townend et al., 2021). A resilience-based approach is framed as one where the objective of coastal management is to increase the ability of coastlines and coastal areas to *respond* to erosion risk (Townend et al., 2021), rather than *reducing* that risk. A resilience-based framing can be seen in the 2010 Flood and Water Management Act, but much more significantly in the more recent 2020 FCERM . However, neither policy document substantiates how resilience to coastal change can be measured (Townend et al., 2021). In the FCERM strategy, resilience is described as enhancing natural and social capacity to respond to flood or erosion events, and reduce economic damage and social harm (EA, 2020), but discusses property and infrastructure resilience in far greater detail than social resilience of people that live in these areas. This corroborates with earlier evidence submitted from the Local Government Association to the Environment, Food and Rural Affairs Committee's (EFRA) 2019 inquiry on coastal flooding and erosion, arguing that beyond property resilience, social resilience is not yet being fully considered in national policy documents (EFRA Committee, 2019). Soon after the release of the current FCERM strategy (EA, 2020), the government announced £200 million for flood and coastal projects in the Flood and Coastal Innovation Programmes (HM Government, 2023a). All of the announced projects focus on building physical or social resilience to coastal change as their principle aim, and/or trialling coastal adaptation (such as the £36 million Coastal Transition Accelerator Programme (CTAP), detailed below).

At a regional level, coastal management authorities in East Anglia (where the case study of this research is situated) have trialled, and are currently trialling, several coastal management approaches focused on building resilience to coastal erosion. The relevant local authorities are North Norfolk District Council (NNDC), Great Yarmouth Borough Council, and East Suffolk Council, who also work in partnership together on coastal management issues through Coastal Partnership East (2022). NNDC are currently running Coastwise, the principal coastal policy of relevance to this research, which is the North Norfolk project on coastal adaptation funded through CTAP. CTAP is a £36 million programme by Defra, running from 2022-2027, that focuses on planning and preparing for coastal adaptation (Defra, 2022). NNDC is one of two local authorities taking part; the other is East Riding of Yorkshire Council, running the Changing Coasts East

Riding project. The two local authorities will trial pilot projects on how at-risk coastal areas can best transition and adapt to rising erosion risk. CTAP is the first time since the 2012 Pathfinder programme (also involving projects in Norfolk) that significant national funding has been allocated specifically to supporting coastal adaptation. Local resident and policymaker perceptions of CTAP are explored in detail in Chapter 6. Other coastal adaptation projects currently underway in East Anglia include other local projects funded through the aforementioned Flood and Coastal Innovation Programme, such as the Resilient Coasts project in Great Yarmouth and Suffolk, trialling the development of adaptation "toolkits" (EA, 2023a, p.1) with local communities. A particular recent focus in East Anglia has been on trialling innovative funding schemes for relocating assets at risk of coastal erosion. This includes CLIFF, or Coastal Loss Innovative Funding and Finance (a local levy), the Local Authority Coastal Adaptation Fund (a funding scheme for at-risk properties), and the Coastal Accumulator Fund (a lifetime fund for properties) (NNDC, 2022a). Therefore, national policy at present is focussed on resilience-based adaptation, with the North Norfolk coast at the forefront of trialling and testing policy developments.

2.2.2 Roles and responsibilities

While policy for managing coastal flooding and erosion is generally set at a national level, and under the responsibility of the EA (POST, 2021), decision-making is led by local authorities, who approve and manage local coastal projects (NNDC, 2016). To do this, local authorities (be it unitary, district or county level) also work in partnership with utility and public infrastructure providers, but can also more widely work with private and third sector groups, and local community groups (Day et al., 2015). This can also involve partnership groups of different stakeholders, such as the Local Government Association Coast Special Interest

Group, and in the context of the Norfolk coast, Coastal Partnership East and the Norfolk Strategic Flooding Alliance. Figure 2.2 below illustrates the breadth of relevant stakeholders, working at different levels and with different remits, on coastal governance. Whereas the national EA has the responsibility for coordinating overall response (Milligan et al., 2009), it is local councils that principally enact policy (POST, 2021). The precise roles and responsibilities at national and local level have evolved over time. Most recently, after devastating flooding across the UK in summer 2007, the Pitt Review (2008) recommended the EA be responsible for a strategy to manage flooding and coastal change, and risk management authorities be responsible for implementing it. These roles and responsibilities were later enshrined in law through the Flood and Water Management Act (2010).

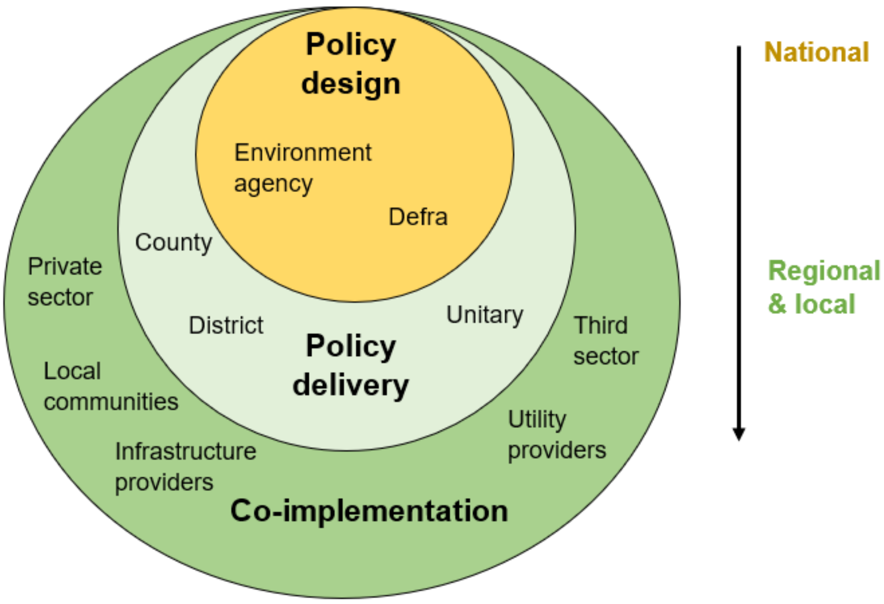


Figure 2.2 Summary of coastal management roles and responsibilities at a national (yellow) and regional/local (green) level. Policy design refers to strategy set by the EA, but through this the government department Defra also has a remit (central sphere, yellow). Policy delivery is actioned by local authorities, of which there are three main types of local government (middle sphere, light green). Key stakeholders are wide-ranging and depend on context and location, but can include a combination of the above (outer sphere, dark green, not exhaustive) (Figure: I Cotton).

The differentiation of responsibilities amongst policy actors is less clear-cut for managing coastal erosion specifically, as opposed to coastal flooding. Although officially district and unitary authorities manage coastal erosion and statutory authorities (the EA) manage flood risk, management often overlaps or aligns, and an agreement on roles is established between different actors (Coastal Partnership East, 2019). Furthermore, and more crucially, no single risk management authority has the capacity for *adaptation* to coastal erosion risk, or to compensate communities and businesses whose properties succumb to erosion (Coastal Partnership East, 2019). As of March 2023, 54 Coastal Erosion Assistance Grants have been provided to local authorities nationally for removing at-risk properties (CCC, 2023), but this grant solely covers the demolition costs to remove houses, and does not provide property compensation. This is in contrast to other European countries, for example France and the Netherlands, where financial support and lease-back options are available (Vermaat et al., 2005; Milligan and O’Riordan, 2007). For example, an insurance scheme providing compensation for natural hazard damage is available in France, funding of which is provided by the government and a national levy on property insurance (French Government, 2022). In England, adapting to coastal erosion can be unreported, and the CCC’s 2023 progress report could not provide a clear assessment of efforts across the UK to adapt to long-term erosion risk (the overall evaluation from the Committee was ‘mixed progress’ specifically because there is no standardised adaptation procedure). Therefore in England, the governance context for adapting to coastal erosion is currently ambiguous, and with a vacuum of designated legal responsibility.

Increasingly, as evidenced in the EA’s (2020) FCERM strategy, local communities are framed as key actors in managing coastal change. Roles described in the strategy document (EA, ibid) include collaborating on coastal management plans and future decisions about local areas at risk. In the document, adaptation is framed in terms of providing "*support*" to high-risk communities to facilitate "*transition*" and adaptation (EA, ibid, p.13). Adaptation and transition is also described as a "*choice*" taken by communities, with support from local authorities (EA, ibid, p.47). This language implies considerable agency on the part of communities on decisions about coastal change, such as decisions about relocating. This raises the question, if local authorities and other risk management authorities play a supportive role in the local delivery of coastal adaptation, who plays the leading role? There is therefore a lack of policy clarity on coastal adaptation in terms of how responsibilities overlap, what specifically communities are expected to do, and who has overall responsibility for coastal adaptation (which, as noted above, is no particular actor's responsibility at the moment). To date, there is less research on community perceptions of their role in coastal management, with previous research focusing on the perspectives of local authorities (Esteves and Thomas, 2014; Van der plank et al., 2020). Perspectives on community roles and responsibilities in coastal adaptation are explored in greater detail in Chapter 7.

Asides from roles and responsibilities, key questions remain on how adaptation to coastal erosion will be funded. The aforementioned adaptation projects in section 2.2.1 are all one-off programmes, with no permanent or designated funding stream for coastal adaptation (EFRA Committee, 2019). Comparing this to coastal improvement works or defences, there are multiple funding streams available at both the national and local level. Two UK government departments provide funding: Defra, and the Department for Levelling Up, Housing and Communities (DLUHC, formerly MHCLG). Of this, the biggest funding stream is from Defra to the EA through Grant-in-Aid (over £1 billion in 2020), which provides funding to local authorities or other relevant risk management authorities (Defra, 2021).

Alongside this centralized funding source, funding may be available through local taxes and levies, other local council budgets, and from third parties (e.g. partnership funding). With tight local authority budgets, local councils have minimal resources to divert such funding to coastal adaptation, and in 2023 the conservative-run Great Yarmouth Borough Council submitted a motion urging central government for more resources to address coastal adaptation needs (EDP, 2023a). At the time of writing, CTAP is the only central government funding stream for adaptation, which is only in two pilot locations (North Norfolk and East Yorkshire) and from 2022-2027.

In their March 2023 progress report, the CCC (2023, p.192) stated that local communities in coastal areas where protection is no longer viable "*should be supported to relocate*". Throughout the document, the only reference to this support is the need for "*subsidies*" for relocation (CCC, ibid, p.196), and it is not specified whom these subsidies should be for, and for what precisely, with regards to relocation. In practice, different coastal areas have different financial support available to them, because public funding streams such as Defra's Flood Defence Grant-in-Aid to the EA require the use of a cost-benefit ratio[3] to justify funds. This entails national-level public funding is awarded according to a utilitarian logic (the greatest good versus money spent) rather than in areas of high priority or vulnerability[4] (Johnson et al., 2007). The environmental justice implications of this approach to determining funding are discussed in section 3.3.3. The cost-benefit ratio approach to funding allocation determines the amount of national government grant awarded, which is combined with any local partnership funding (Defra,

[3] 'Benefits' are understood as the economic cost of future damages avoided by introducing a coastal management or coastal defence scheme (HM Government, 2018).

[4] Although there is some evidence of the Treasury taking a vulnerability-based approach to awarding funding, in the way different areas are assessed as 'valuable'. The characteristics of a neighbourhood are not valued 'like-for-like', for example households, and socially vulnerable households, are valued more greatly than businesses or general physical infrastructure (HM Government, 2018).

2021), such as local community groups, local enterprise partnerships, or private finance, to fully fund a scheme (EA, 2020).

To conclude for section 2.2, coastal management policy in the UK has evolved from a risk-based to a resilience-based approach, with significant social implications for coastal areas that will no longer receive funding for coastal defences. There is currently little practical guidance on how resilience in coastal management can be achieved or measured. Furthermore, there is little clarity around fostering and supporting coastal adaptation, with no clear roles, responsibilities and funding sources (other than the current CTAP in Norfolk and East Yorkshire). This includes little practical guidance on how communities are expected to be involved, despite policy rhetoric. Consequently, key questions surrounding the ‘what’ ‘who’ and ‘how’ for coastal adaptation are still very much unanswered. The next section in this chapter will outline different approaches to managing coastal risk, and introduce mega-nourishment, the coastal management approach used in this thesis’ case study area.

2.3 Introduction to mega-nourishment

2.3.1 Different coastal management approaches

In terms of geology, beaches are a type of depositional coastal landform, formed and altered by the movement of sediment through wave and tidal dynamics. Deposition of sediment occurs when these dynamics exist at a low rate. Beaches take varying shapes (i.e. gradients) depending on these dynamics and (sediment) grain size, resulting in dissipative (low gradient) or reflective (high gradient) beaches. However, beach shape will vary considerably across the seasons, with a net migration of sediment onshore during summer, when waves have minimum swell and steepness, and offshore during winter. As a result, a summer beach has a steeper profile than during the winter months. This is significant for erosion risk, which is therefore greater during winter, without the protection of beach height and ample sediment. Sediment is transported to and from beaches, and cross-shore, through the process of longshore drift. A coastal system with a negative sediment budget (i.e. greater sediment material removed than deposited) will result in erosion. The opposite (i.e. a positive sediment budget) will result in accretion, but coastal systems can also be in equilibrium through balanced sediment budgets, with no significant change to the position of the coastline (Leeder, 2011).

Coastal management approaches work in different ways to affect these geological processes, targeting either the dissipation of wave energy and/or reducing tidal flow velocity. Hard defences, such as sea walls and revetments, do both, forming a physical barrier between waves and the land. However hard defences can be problematic for multiple reasons. Reducing cliff erosion in a particular area can affect sediment budgets for adjacent beaches (Ballinger and Dodds, 2020). Thus, this can actually increase the vulnerability to erosion for neighbouring coastlines, through reduced sediment accretion. As well as inhibiting the movement of sediment, hard engineering structures can be detrimental to marine flora and fauna (Hanley et al., 2014). Therefore, hard engineering approaches have been criticised as failing to account for long-term coastal processes, local ecology, wider spatial areas, and future climate risk (Ballinger and Dodds, 2020).

Conversely, the other main approach to coastal management, so-called ‘soft engineering’, is increasingly being adopted because it works with, rather than inhibits, natural coastal processes (Buser, 2020). As Figure 2.3 illustrates, most coastal management interventions fall into either a hard defence or soft engineering category (although hybrid or green-grey approaches also exist, for example, habitat tiles on sea walls) (Chapman and Blockley, 2009). Soft engineering approaches, which can also include ecosystem-based approaches or nature-based solutions, are now generally considered more desirable than hard engineering because they are iterative and evolving, responding to coastal stresses rather than being static (Spalding et al., 2013). Where hard defences sought to resist coastal change, nature-based solutions reduce risk by mimicking or working alongside natural coastal processes, and through this, potentially transforming coastal areas into fundamentally different systems (Spalding et al., 2013; Buser, 2020). Nature-based solutions can both minimise the impacts of events, and increase adaptive capacity to respond to future events (Seddon et al., 2021). This is argued to lead to better societal and environmental outcomes (Chausson et al., 2020; Seddon et al., 2021) and can enhance ecosystem services (Vikolainen et al., 2017). In turn, greater ecosystem services can improve coastal processes, and thus coastal resilience, as increased coastal functioning can enhance a system’s capacity to absorb shocks such as extreme storm events. While potential drawbacks to nature-based solutions can include requiring a bigger spatial area than certain hard defences, this is not the case for all types, with mega-nourishment requiring no extra (inland) space, and reinforcing a landscape already present (Spalding et al., 2013).

Figure 2.3 Different types of hard and soft engineering approaches to manage coastal risk (according to literature). Figure 2.3 is not exhaustive and serves as an illustration only of the most common types (Figure: I Cotton).

Commonly deployed coastal nature-based solutions in the UK include wetland restoration (e.g. saltmarshes), and beach nourishment, however there are also active projects for marine (off-shore) nature-based solutions such as sea grass and kelp forests (POST, 2021). Saltmarshes and beach nourishment work by dissipating the energy of waves through vegetation and the enhanced deposition of sediment (in the case of salt marshes) or dunes/increased sediment supply and wider beaches (in the case of beach nourishment) (Moller et al., 2020). Although existing research has indicated saltmarshes may only be effective at certain water depths and wave energies, other studies have shown that wave energy is still dissipated by saltmarshes under high water depth and wave energy scenarios (Moller et al., 2014), suggesting there is still a benefit to saltmarshes in any environment. This provides coastal frontages with protection from waves and storm surges, lowering the risk of flooding or erosion (Hanley et al., 2014). Other nature-based solutions include dune restoration, common across northern Europe, which induces sediment redistribution across the coast and increases biodiversity (Laporte-Fauret et al., 2021). For offshore nature-based solutions (kelp forests and seagrass meadows), coastal protection is provided indirectly through biological characteristics, where species reduce the impact of waves (Hanley et al., 2014). Overall, soft engineering approaches offer flexible, adaptive coasts, where beach profile varies year to year and seasonally (Hanley et al., 2014).

The use of soft engineering has increased in recent years, with the EA's current FCERM strategy (2020) doubling the funding allocated for nature-based solutions in England and Wales. This contrasts with the aftermath of the 1953 floods, where hard defences dominated (Nicholls et al., 2013) and the roll-out of hard engineering accelerated to maintain the 'hold the line' policy for much of England's coastline (O'Riordan et al., 2014). Therefore the move from a risk-based to resilience-based approach to coastal policy, as outlined in the previous section, has mirrored a move from hard defences to soft engineering approaches. Soft engineering approaches have become increasingly innovative in recent years, with mega-nourishment in Norfolk in 2019 (this thesis' case study, outlined in section 2.4.3) and coastal wetland restoration in Essex in 2018 becoming the largest-scale implementation of their kind in England (RSPB, 2023; Johnson et al., 2020b). Given their novel approach and scale, understanding whether innovative nature-based solutions are effective – or not - is now critical to informing the roll out of similar schemes in the future. The next section outlines the use of beach nourishment and mega-nourishment in greater detail, as the latter is the coastal management approach analysed in this study.

2.3.2 Mega-nourishment: a scaled-up form of beach nourishment

First introduced in the UK in the 1960s (Buser, 2020) beach nourishment was initially used to increase the longevity of existing hard defences (Hanson et al., 2002). Also referred to as ‘sand replenishment’ and ‘beach fill’ (de Schipper et al., 2021), early projects on the south coast redistributed shingle sediment between different areas of coastline, with the first dredging of sand taking place in 1972 (Hanson et al., 2002). Existing schemes in England include the Lincshore project in Lincolnshire, which began in 1994 (EA, 2019). Beach nourishment is the regular placement of additional sand on vulnerable beaches to increase beach volume. Sand is replenished typically every few years (Stive et al., 2013), or when monitoring indicates beach volume has fallen below a certain threshold (Walkden et al., 2015). Unlike hard defences, beach nourishment does not inhibit, and rather supports, the coastal processes that allow transportation of sediment (de Schipper et al., 2021), with sediment migrating updrift and downdrift from the location of its original placement.

While offering relatively fewer impacts on coastal environments than other approaches (Moreno and Munoz-Perez, 2021), the success of beach nourishment is sensitive to choice of grain size (Hanley et al., 2014). Too coarse (or too fine) grain size may be ineffective, and cause marine biological impacts (Hanley et al., 2014; Parkinson and Ogurcak, 2018), for example a decline in habitat suitability and abundance of some species as observed by Peterson et al., (2006). Further, beach nourishment schemes have been criticised for their overall cost, high sediment supply requirements (Parkinson and Ogurcak, 2018) and for considering too narrow spatial scales in their assessments (Lazarus et al., 2011), by failing to consider the effect of nourishment on neighbouring beaches and the broader coastal system (Lazarus et al., 2011; Gopalakrishnan et al., 2018). Parkinson and

Ogurcak (ibid) also criticise the use of beach nourishment as only delaying inevitable forced retreat for at-risk areas, and is therefore not a long-term solution.

Over the last decade, a significantly scaled-up type of beach nourishment has been attempted to manage coastal change, known as ‘one-off’ or ‘mega-nourishment’. The Zandmotor project in the Netherlands, which deposited 21.5 million m^3 sand near the Hague in 2011, is the first mega-nourishment approach implemented worldwide (Bontje and Slinger, 2017; Climate ADAPT, 2019), and inspired the design of mega-nourishment projects at Bacton and Walcott in the UK (the case study of this research) and Togo and Benin (The Maritime Executive, 2022). Beach nourishment has regularly occurred across the Dutch coast since the 1990s, but the Zandmotor scheme is a dramatic and innovative expansion of this process on a much larger scale (Mulder and Tonnon, 2010). For example, the volume of sediment used in the Zandmotor scheme (21.5 M m^3) is greater than that used across the entire Dutch coast for beach nourishment annually (Bontje and Slinger, 2017), and corresponds to placing 10,000 m^3 sand for every metre of beach (Mulder and Tonnon, 2010). The difference between beach nourishment and mega-nourishment is not precisely defined, but considered to be a placement of greater than 500m^3 sediment per metre (de Schipper et al., 2021). In mega-nourishment, sediment is distributed over a much smaller lateral area, so that the beach extends further into the sea than traditional beach nourishment (Stive et al., 2013) (see Figure 2.4).

Figure 2.4 The initial extent of placed sediment in the Zandmotor scheme © Rijkswaterstaat / Joop Van Houdt, subsequently reprinted in Stive et al., (2013).

Mega-nourishment is considered to have many advantages over smaller-scale beach nourishment. While both processes use the same mechanism (i.e. gradual redistribution of sediment over time through natural coastal processes), the bigger size and scale of mega-nourishments means it lasts much longer (up to 20 years, compared to a few years for beach nourishment (Stive et al., 2013)). Crucially, unlike beach nourishment, mega-nourishments do not require regular intervention (de Schipper et al., 2021). For this reason, they can be more cost-effective (Slobodan and Walvin, 2015), quicker to implement (Moreno and Muñoz-Perez (2021), and therefore more viable in contexts where beach nourishment is unfeasible (Brown et al., 2016). Environmental impacts can be minimised more quickly, whereas regular sand placement may exacerbate impacts because of an absence of recovery period for coastal systems (Moreno and Muñoz-Perez, 2021). The Zandmotor scheme is also expected to offer wider ecological benefits, such as supporting dune formation and new ecological communities (van Bergen and Nijhuis, 2020).

Research thus far on mega-nourishment schemes (principally the Dutch Zandmotor scheme, given it was the first scheme of its kind in 2011), has focused on analysing how the coastal environment is responding geomorphologically or ecologically. This has been widely studied for the Zandmotor scheme, for example De Schipper et al., (2016) on movement of placed sediment; Hoonhout and de Vries, (2017) on the dynamics of wind-blown sand and dune formation; Luijendijk et al., (2017) on factors affecting placed sediment movement, including wave dynamics, and Roest et al., (2021) on a comparison of erosion and accretion and different beach depths. The last sub-section of this chapter (2.4.3) explores initial findings of the geomorphological development of the Zandmotor scheme in further detail, comparing this to the modelled expectations of the Bacton-Walcott sandscaping scheme. There has also been research on the ecological implications of the Zandmotor scheme (for example Van Puijenbroeck, 2019), in terms of impacts to the number of species living in the intertidal zone (Herman, 2019), the impact of placed sediment on juvenile fish nursery areas (Post, 2019), and the suitability for dune plant species (Pit et al., 2020). The Zandmotor scheme has also been used as a case study in technological developments for remote scanning and field measurements (Vandebroek et al., 2017).

What is comparatively lacking is research into the social impacts of mega-nourishment. One of the few existing studies from a social perspective has focussed on exploring mega-nourishment's unique (i.e. multi-stakeholder) governance arrangements (Bontje and Slinger, 2017; Flikweert, 2017; Vikolainen et al., 2017). Furthermore, the five year monitoring report of the Zandmotor scheme (Taal et al., 2016) solely assessed social impacts in terms of recreational changes (through public surveys), such as implications of geomorphological change for swimming (Radermacher, 2018) but this does not draw on social perspectives from beach users themselves. Similarly, the 10-year evaluation report of the Zandmotor scheme continued a geomorphological and ecological focus, with social dimensions limited to exploring recreational changes for local users (Huisman et al., 2021). More recent research on mega-nourishment (Day, 2020; Day et al., 2023; Vreugdenhil and Slinger, 2023) has examined social perceptions, focusing on the social impacts and added value of the scheme. Social perceptions of mega-nourishment have therefore to date been explored specifically in the context of recreational preferences or social impacts, with unexplored dimensions on public acceptability, perceived effectiveness, or the impact of mega-nourishment on perceptions of wider coastal change. This mirrors a gap in the literature where there is also a lack of research on public perceptions of smaller-scale beach nourishment. As explored in greater detail in Chapter 5, while public perceptions of beach nourishment have been well studied (for example Lozoya et al., 2014; Prati et al., 2016; Cabezas-Rabadán et al., 2019), research with policy-makers, stakeholder organizations (Ariza et al., 2014; Bontje et al., 2019), and recreational beach users (Cabezaz-Rabadán et al., 2019; Usher, 2021) is more extensive compared with local residents. Therefore, more needs to be known about the wider social impacts of mega-nourishment, and how it is perceived by the public. The final section of this chapter introduces the case study of this thesis: the villages of Bacton, Walcott and Happisburgh, and the Bacton-Walcott sandscaping scheme.

2.4 Introduction to case study

2.4.1 Geography and demography

The case study area for this thesis is the villages of Bacton, Walcott and Happisburgh, on the North Norfolk coast of England. Bacton, along with the adjacent villages of Walcott and Happisburgh, are situated south of Cromer and approximately 20 miles north-east of Norwich (see Figure 2.5). Bacton Gas Terminal lies to the west of Bacton village, and has been operating since 1969

(Shell, 2021). The terminal is a significant piece of energy infrastructure, responsible for a third of the UK's gas consumption (Shell, 2021).

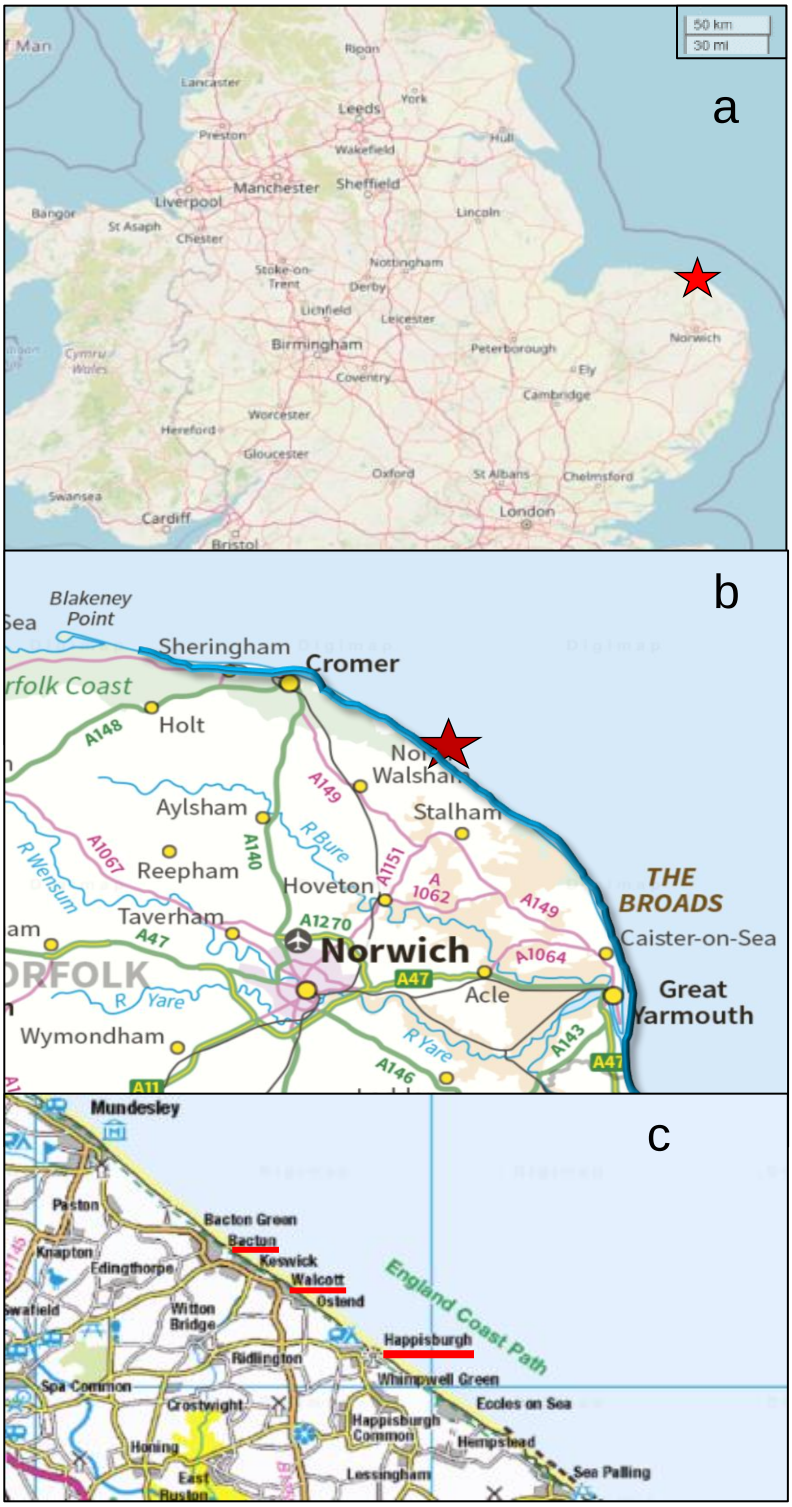


Figure 2.5 Case study location on the East coast of England (starred in map a and b). The area sits within SMP 6 (Kelling Hard to Lowestoft Ness), which is denoted with a blue line in map b. The three case study villages are underlined in red in map c © Edina Digimap

Bacton is the largest of the three villages, with an estimated population size of 1,194 residents, followed by Happisburgh (889) and Walcott (548) (ONS, 2011[5]). All three villages are sparsely populated (in the lowest 20 percentile nationally), with a population density below 1,000 people per square kilometre (ONS, 2021), The villages, like many other parts of Norfolk, are rural. The majority of land use in North Norfolk (72%) is agricultural, with only 5% land taken up for developed use (MHCLG, 2020).Tourism and agriculture are the main sources of revenue to the local area, with several holiday parks, hotels, and holiday cottages across the three villages. 14% of properties in Bacton are classified as second homes or holiday lets, a figure that has increased year on year since 2017 (NNDC, 2021).

The villages are ranked in the 3rd (Walcott and Happisburgh) and 4th (Bacton) most deprived deciles in England's Indices of Multiple Deprivation, with low crime rates (10th decile), average income and access to healthcare (5th decile), but low access to housing and other services (1st decile) (MHCLG, 2019). The villages have higher than average older populations, with 36% of residents in the surrounding Bacton area, and 27% of residents in the surrounding Walcott and Happisburgh area, aged 65 and above (ONS, 2021). Correspondingly, 74-85% of residents are not in employment (nor for the last 12 months) (ONS, 2021). Figures 2.6-2.8 overleaf show a series of images of the three villages.

[5] Due to the way in which Lower Super Output Areas are presented in the 2021 ONS dataset, it is difficult to obtain population estimates solely for each village, and therefore update population estimates beyond the ONS (2011) census.

Bacton

Figure 2.6 Mosaic of images of Bacton (Photos: I Cotton)

Walcott

Figure 2.7 Mosaic of images of Walcott (Photos: I Cotton)

Happisburgh

Figure 2.8 Mosaic of images of Happisburgh (Photos: I Cotton)

2.4.2 History of coastal management

The coastline from Bacton to Happisburgh is highly physically vulnerable to coastal erosion and extreme storm events. Unconsolidated cliffs, comprised of rock types such as clay and fine sands (Royal HaskoningDHV (RH), 2017), are highly susceptible to erosion, and have been in retreat for several thousand years (Wingfield and Evans, 1998), in part due to the East of England subsiding (Nicholls et al., 2013). See Figure 2.9 for images of the cliffs at Happisburgh. The Norfolk coast has seen one of the biggest UK rates of sea level rise in the late 20th century (Woodworth et al., 2009). Between 1885-1968, the long-term average cliff erosion rate at Bacton was estimated to be 0.52 metres per hectare (Brooks and Spencer, 2019). In the 1960s erosion rates slowed, due to the installation of local hard defences (Brooks and Spencer, 2019; Payo et al., 2020). Examples of historical hard defences (shown in Figure 2.10) includes timber groynes, revetments, and concrete walls (at Bacton and Walcott) (RH, 2018a), and revetments and rock armour (at Happisburgh) (Payo et al., 2020). Hard defences at Happisburgh failed in the 1990s, some of which were subsequently removed, which further accelerated erosion rates (Payo et al., 2020). As outlined in the introduction (section 1.1), environmental change is also intensifying due to the consequences of climate change (sea level rise and more frequent and intense storms). Consequently, erosion rates in the villages in the 21st century exceed historical averages, and were calculated to be 4m yr^{-1} between 2013-2018 at Bacton and Walcott (Rumson et al., 2019) and, in some locations, 8-10m yr^{-1} at Happisburgh (at the turn of the century, Payo et al., 2020).

Coastal erosion manifests in significant and permanent impacts for the local communities in each village. Farmland and residential buildings have frequently been lost in the past at Happisburgh (BGS, 2021), and 35 residential properties have been lost, as of 2019, due to erosion (EFRA Committee, 2019). A caravan park was relocated away from the cliff edge in 2012 (Frew, 2012). All three villages were significantly affected by the 1953 and 2013 floods (Mott MacDonald, 2016; BGS, 2021), and during the winter 2013 storm alone, the cliffs at Bacton retreated 5-10m (Vikolainen et al., 2017).

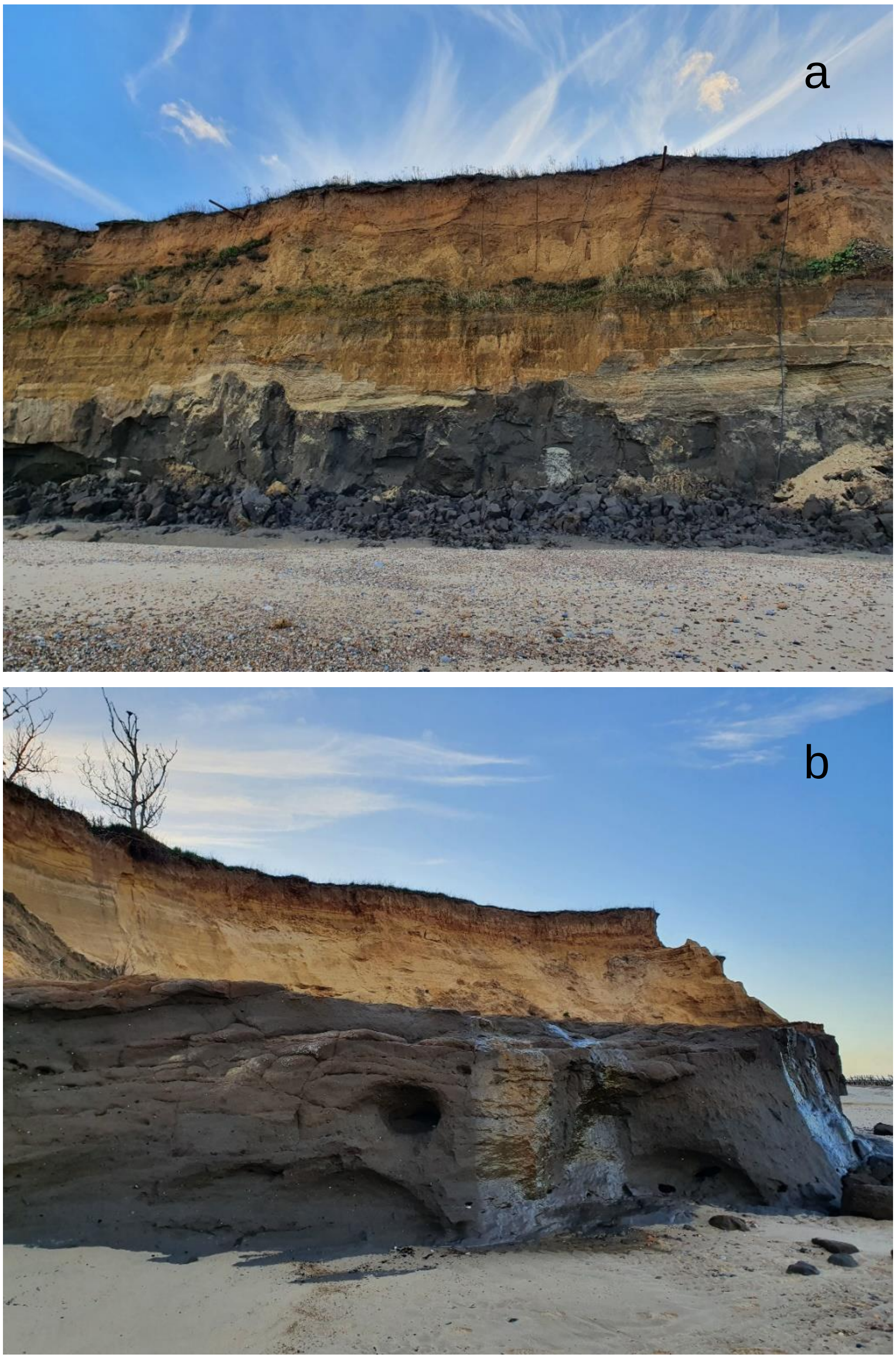


Figure 2.9 Soft substrate cliffs at Happisburgh (Figure a and b). Cliff vulnerability to erosion at Happisburgh is also exacerbated by surface runoff (observable in Figure b) (Photos: I Cotton).

Figure 2.10 Existing or redundant hard defences at Bacton, Walcott and Happisburgh. This includes damaged structures (a, Happisburgh) rock armour (b, Happisburgh) revetments (c, Bacton, now partially submerged by sediment from sandscaping), and groynes (d, Walcott, now partially submerged by sediment from sandscaping) (Photos: I Cotton).

Bacton, Walcott, and Happisburgh are part of SMP 6, which encompasses Kelling Hard to Lowestoft Ness (AECOM, 2012a) (see map b, Figure 2.5). Contrary to the first iteration, the second SMP designates the coastline from Bacton Gas Terminal to Happisburgh as areas where continual protection to 2100 is not feasible. If hard defences continue to be strengthened, the SMP argues, areas past Winterton (south of Happisburgh) will become more vulnerable to coastal erosion. Several studies have highlighted the benefit of such an SMP approach to sediment budgets for the coastline as a whole. Hall et al's. (2015) modelling study demonstrates the benefit of allowing cliffs from Sheringham to Happisburgh to erode naturally, feeding low-lying cliffs past Happisburgh to Winterton, increasing beach volume and providing flood protection to the coast and the Norfolk Broads. Meanwhile, the implementation of the first phase breakwaters at Sea Palling in Norfolk was modelled by Thomalla and Vincent (2003) as responsible, through the creation of tidal tombolos (narrow stretches of sediment or spits), for cutting off the distribution of sand at Winterton. Consequently SMP 6 recommends a 'hold the line' policy for Bacton Gas Terminal, managed realignment from present day at Happisburgh, and from 2025 at Bacton and Walcott. Figure 2.11 illustrates the areas of Bacton and Walcott vulnerable to erosion (in red or orange shading), at different periods into the future. SMP 6 recommends maintaining defences no longer than is required to develop necessary plans for relocation or other options, expected to be required towards the end of this century (AECOM, 2012a).

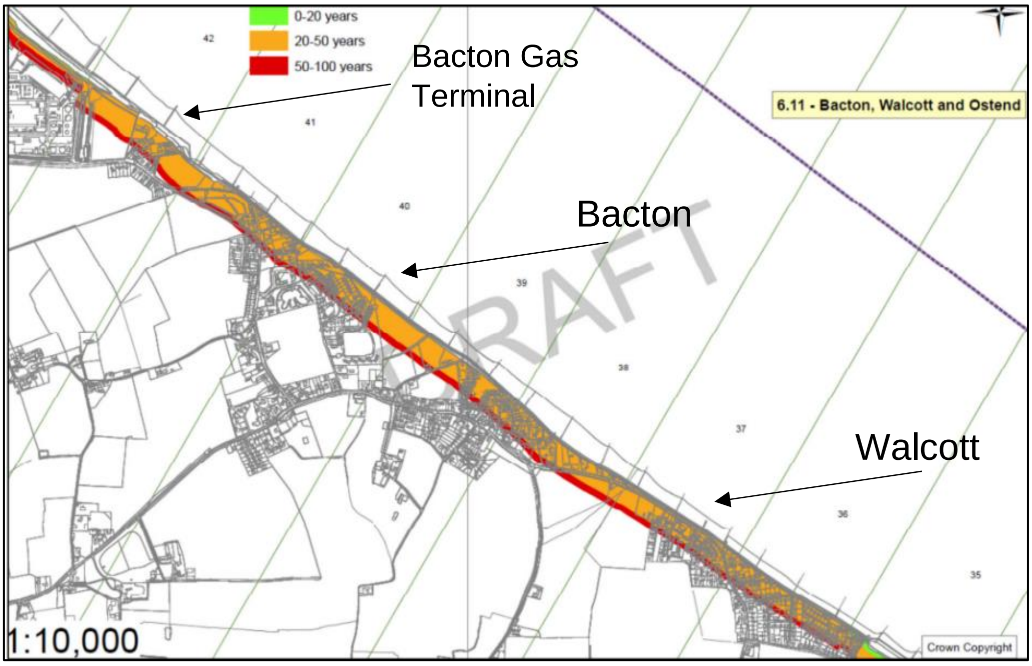


Figure 2.11 Areas vulnerable to coastal erosion at Bacton and Walcott, under a 'hold the line' scenario to 2025, and managed realignment scenario thereafter (annotated from Mott MacDonald, 2014) Orange shading indicates areas susceptible in 20-50 years, red shading 50-100 years.

The change from 'hold the line' to 'managed realignment', following the publication of the second Kelling Hard to Lowestoft Ness SMP in 2005, was met with widespread dismay by local communities (Milligan et al., 2009). A public consultation on the draft document received 99.6% objections (of approximately 2,400 local residents that responded) (CCAG, 2023a). 'Managed realignment' or 'managed retreat' refers to the deliberate process of allowing the shoreline to move inland, for areas at risk of erosion or flooding (AECOM, 2012a). It ensures natural processes control the rate of coastal change, without intervention or defences that may slow the process. Given the loss of land and property associated with the policy, it is a contentious SMP policy designation. As section 2.2.1 outlines, the change to managing coastal risk at Bacton, Walcott and Happisburgh under a 'managed realignment' policy is therefore an abrupt, opposing approach to the previous 'hold the line' policy, and the continual protection communities had for decades (Nicholson-Cole and O'Riordan, 2009; Nicholls et al., 2013).

After hard defences failed in the 1990s at Happisburgh, no further defences have been introduced (apart from piecemeal measures such as introducing rock armour in the 2000s) (Law et al., 2011). The coastline at Happisburgh has therefore been largely undefended over the last 30 years. This was despite a series of proposals for coastal schemes in the 1990s and 2000s, however, no proposal met the cost-benefit ratio for the local authority to justify use of public funds (CCAG, 2023b). The local community have continued to run a long and at times high-profile campaign about the lack of coastal defences (particularly following the revised SMP publication in 2005), reaching national and even international news (Tebboth, 2014; CCAG, 2023c). This included forming a Coastal Concern Action Group (CCAG), which inspired and networked with many local coastal campaign groups across the country (CCAG, 2023b). Local residents articulated calls for social justice, in requesting financial support and greater involvement in coastal decision-making (Tebboth, 2014; Famuditi et al., 2018). After news in 2004 of the upcoming SMP update, local residents set up a charity to crowdfund for hard defences (of which £40,000 was raised in the first few years), including the 'buy a rock for Happisburgh' campaign (Law et al., 2011). Happisburgh residents refused to engage with local authorities if compensation for affected community members would not be considered, and social impacts relating to coastal erosion, such as property loss and forced relocation, were repeatedly discussed between NNDC and the community (Milligan and O'Riordan, 2007).

While community campaigning did not lead to a change in SMP policy, in 2012, Happisburgh was one of 15 locations across England to receive funding as part of the Pathfinder programme, a central government funded programme to trial innovative property roll-back and coastal adaptation options (Frew, 2012). The £3 million pathfinder project in Happisburgh involved the demolition of houses and a caravan park near the cliff edge, later using some of this land for a new car park, revenue of which goes to the parish council (Frew, 2012). Thus, although the Happisburgh Pathfinder programme did not strictly provide property compensation, for residents who lost homes to coastal erosion, affected individuals were offered a plot of land elsewhere, which could either be built on or sold. This was later introduced into local government planning policy (NNDC EN12 Policy – Relocation and Replacement of Development Affected by Coastal Erosion Risk) (NNDC, 2023a). Happisburgh residents continue to campaign for coastal defences and policy support, now under the banner of the ‘Save Happisburgh Action Group’. On the Facebook page for the campaign group, its articulated aims are to provide physical protection to the village, financial support to at-risk homeowners, and preserve the many historical sites in Happisburgh (Save Happisburgh Action Group, 2023).

At the time of the revised SMP publication in 2005, Bacton and Walcott were in a slightly different position than at Happisburgh. The change from ‘hold the line’ to ‘managed realignment’ was due at 2025, rather than the then present-day, and there were pre-existing hard defences protecting the coastline (Mott MacDonald, 2014), including timber groynes, revetments, and a concrete sea wall (RH, 2018a) that runs along much of the seafront at Bacton and Walcott villages. Despite these defences, Bacton and Walcott are still vulnerable to flooding and erosion, and nearly 200 local businesses and homes were flooded in the two villages following the damaging December 2013 floods (Mott MacDonald, 2016). The damage caused by the 2013 floods caused deep concern with local residents that a similar event could reoccur in the future (Day, 2020). A flood support group was set up on Facebook in the aftermath of the 2013 floods, which continues to this day. At the time of writing, the group has over 3,000 members on Facebook, which is roughly the same size of the total population for all three villages (ONS, 2011) suggesting inland and neighbouring community support within the group.

In 2014, the pre-existing hard defences at Bacton and Walcott were assessed as not in their optimum state and in need of repair (Mott MacDonald, 2014). The residual lifetime was calculated to be 15 years for the timber revetments and sea walls, and 5-10 years for the groynes (AECOM, 2012b), putting over 200 properties at risk of coastal erosion (as illustrated in Figure 2.11, Mott MacDonald, 2014). Several feasibility studies of different options to manage coastal change were explored by the local authority, including a range of hard defence reinforcements, soft engineering, or no active intervention (Mott MacDonald, 2014: 2016). Of particular consequence was the high vulnerability of Bacton Gas Terminal to erosion, which is located north of Bacton village and was only several metres from the cliff edge. The local authority, with the support of significant partnership funding from Bacton Gas Terminal, subsequently chose to introduce a large-scale mega-nourishment project to protect the terminal and adjacent coastline (sandscaping), which will be outlined next, the final section to this chapter.

2.4.3 The Bacton-Walcott sandscaping scheme

In July 2019, a mega-nourishment scheme was implemented at Bacton to protect the nationally important Bacton Gas Terminal from flooding and coastal erosion (NNDC, 2022b). Known locally as sandscaping (rather than mega-nourishment), the Bacton-Walcott sandscaping scheme is modelled from the Zandmotor project in the Netherlands (Johnson et al., 2020b). While the sandscaping scheme at Bacton is much smaller than the Zandmotor scheme (1.8 million m^3 placed sediment, compared to 21.5 million m^3 for the Zandmotor) (De Schipper et al., 2016; Johnson et al., ibid), it is still on a vastly greater scale to traditional beach nourishment: the initial placed sediment stretched for 6km at Bacton (Johnson et al., 2020b), whereas existing beach nourishment schemes typically target a particular beach. Figure 2.12 indicates the extent of placed sediment in 2019. Note that Bacton and Walcott are in, but Happisburgh is outside, the area of initially placed sediment, and therefore the area that was intended for coastal protection from the scheme.

Figure 2.12. Red shading indicates the area of initial placed sediment and coastal protection of the sandscaping scheme, July 2019 (annotated from © Edina Digimap

The Bacton-Walcott sandscaping scheme is the first use of mega-nourishment in the UK. The shape of the sandscaping scheme differs from the Zandmotor scheme: placed sediment was spread further along the coastal frontage, resulting in no peninsula as in the Zandmotor scheme (Stive et al., 2013). However, the mechanism with which it provides coastal protection is the same: over time, the significant volume of additional placed sediment will gradually erode, be transported and deposited further up and down the coast through wave, tide, and inshore wind action. Sandscaping initially raised the height of Bacton beach by 7m, and the increased beach volume and height acts as a barrier between wave energy and erosion at the base of the cliffs (Hall et al., 2015). Figure 2.13 shows before and after photographs of Bacton gas terminal as a result of sandscaping, illustrating this transformation.

Figure 2.13. Before (top, July 2018) and after (bottom, Sept 2019) photos of Bacton Gas Terminal © Mike Page.

The Bacton-Walcott sandscaping scheme cost approximately £21 million (Johnson et al., 2020b), and was therefore a hugely costly coastal management scheme. The primary reason why sandscaping was implemented at Bacton was the need to protect the nationally important Bacton Gas Terminal against coastal risk (CCC, 2018). As previously mentioned, the terminal was only metres from the cliff edge before sandscaping was introduced. Now that sandscaping has been implemented, the terminal is expected to be protected from flood and erosion for 15-20 years. Meanwhile, the adjacent villages of Bacton and Walcott are expected to be protected for at least that timespan.

A significant proportion of funding for the Bacton-Walcott sandscaping scheme was from the private sector: two-thirds of the £21 million came from the terminal operators (Shell and Perenco), with the remaining funding supplied by Defra (through FCERM Grant in Aid), the EA, NNDC, and funding contributions at a local level (such as crowdfunding) (Johnson et al., 2020b). The scheme was first conceptualised in the aftermath of the December 2013 floods, which highlighted the need for coastal protection at the terminal, and where several metres of erosion had occurred. At this time, RH undertook a feasibility study for NNDC and the Crown Estate in 2013, which highlighted that mega-nourishment would be a technically feasible coastal management option for this stretch of coast. (Johnson et al., 2020b). The placed sediment used in sandscaping was sourced from a licensed extraction site on the seabed at Great Yarmouth (Vikolainen et al., 2017). This placed sediment is of a similar grain size, or in certain cases coarser, than the pre-existing sediment on Bacton and Walcott beaches (Vikolainen et al., 2017).

Following the feasibility study, conversations about the viability of sandscaping continued for several years between the EA, NNDC, RH, the Crown Estate and terminal operators, evolving into a partnership (Johnson et al., 2020b). This included numerous consultations with key stakeholders from 2014-2017, such as Natural England, the Marine Management Organisation (MMO), and the Eastern Inshore Fisheries and Conservation Authority (IFCA) (Vikolainen et al., 2017). Public engagement also took place at this time, comprising of a consultation on the environmental assessment of the scheme, through press releases, and meetings with local groups (e.g. between NNDC and parish councils) (Vikolainen et al., 2017). Further detail about public engagement on the sandscaping scheme is provided and focussed on in Chapter 5 (section 5.2.2), as it is particularly pertinent to empirical results presented in that chapter.

The Bacton-Walcott sandscaping scheme is described - by local and national policymakers and the engineers that designed the scheme (RH) - as providing additional time and opportunities for the villages of Bacton and Walcott to prepare for and adapt to the risk of flooding and erosion in the future (RH, 2018a; Johnson et al., 2020b). The scheme is therefore framed as an innovative coastal management strategy that builds social, as well as environmental, resilience to future coastal change, because it allows time to prepare for adaptation. Perceptions of future coastal change at Bacton and Walcott post-sandscaping is a key theme of this research, explored in Chapter 7.

What are the modelled geomorphological changes of the sandscaping scheme, and is it working as expected?

The sandscaping scheme is being monitored by RH on behalf of NNDC. This includes regular bathymetric and topographic survey campaigns[6], twice a year, of geomorphological changes above and below mean sea level. This secondary dataset is analysed in this thesis, to investigate beach profile and volume changes, alongside changes to the rate of cliff retreat. As of Autumn 2023, five survey campaigns have been conducted (August 2019, October 2019, February 2020, November 2020, June 2021 and September 2021) (RH, 2022a). Data from the monitoring campaigns show the sandscaping scheme is working broadly as it was expected to. Modelled expectations were that the nourished beaches would lose sediment over time, both seaward and alongshore, but for the majority of this placed sediment to remain in the coastal system over the scheme's lifetime, rather

[6] The topographic surveys use LIDAR technology, and the bathymetric surveys use single beam jet skis. The resolution of both surveys is 0.5m x 0.5m.

than lost offshore (NNDC, 2022b). In the first two years post-sandscaping, an estimated 276,000m^3 placed sediment has migrated (representing 16% of the overall 1.8 M m^3 sand placed initially). 46,000m^3 of the 276,000m^3 migrated sand has moved in a south-easterly direction. There has therefore been a net erosion of sediment at Bacton Gas Terminal in the first two years, but net accretion at Bacton and Walcott village (NNDC, 2022b). This movement is expected, given the majority of sediment was placed at Bacton Gas Terminal, and therefore it is the terminal that was expected to see the greatest net sediment volume decrease over time, feeding areas updrift and downdrift.

These early geomorphological changes of the sandscaping scheme broadly mirrors the evolution of the Zandmotor scheme. The 4-year Zandmotor evaluation estimated that 95% of placed sediment still remained in the immediate area in the Delfland coast (Taal et al., 2016). This was higher than the modelling predicted, which suggests the Zandmotor scheme could exceed its 20 year predicted lifetime (Taal et al., 2016). For the sandscaping scheme, this figure was 84%, in the first two years (RH, 2022a). Unique local factors are expected to explain lower than expected sediment loss for the Zandmotor scheme, such as additional migrating sand from neighbouring beaches by prevailing winds, and placed sand from a nearby beach nourishment process in 2013 (Taal et al., 2016). Overall, placed sediment from the Zandmotor scheme has been transported 3.6km further along the coast than the 2.2km extent of its original placement (Taal et al., 2016). Geomorphological analysis by RH of the sandscaping scheme (2020: 2022a) found sediment accretion at Happisburgh, approximately 2 miles south of Walcott, the southern boundary of initially placed sediment. This is an unintended and potentially positive impact of the sandscaping scheme, in offering protection from erosion to a greater stretch of coastline than anticipated. Increased sediment volume and beach width at Happisburgh can be observed in the data (RH, 2022a).

Sediment accretion, in the upper intertidal zone and the shoreface, has also increased updrift of the sandscaping scheme, at Mundesley (RH, 2022b). However, crucially, it is unknown how much sediment will arrive at Happisburgh and how long it will remain.

2.5 Concluding remarks

In conclusion, this chapter has provided the reader with the necessary background to the research, providing an overview of coastal management policy and strategies to manage coastal risk, focusing in particular on mega-nourishment. The case study of the research, the Bacton-Walcott sandscaping scheme, has been introduced, with a history of coastal management at Bacton, Walcott, and Happisburgh. Key findings from this chapter include a lack of policy clarity on building social resilience to coastal change and facilitating coastal adaptation, despite the attention and use of resilience as a concept in recent coastal policy documents, and a research gap on exploring the social dimensions of sandscaping. The next chapter will outline the academic fields of study on resilience and adaptation, alongside environmental justice, in a literature review, drawing upon previous research to develop a conceptual framework for the thesis.

3. Literature review

3.1 Introduction

This literature review draws upon three main research topics to study coastal change – the resilience (section 3.2), environmental justice (3.3), and adaptation (3.4) literature. As much studied research fields, this review focuses on UK and European coastal contexts, given the case study of this thesis is the North Norfolk coast. The linkages between these topics form an important part of this thesis' conceptual framework, outlined in section 3.5. The academic and grey literature presented in this review were identified through keyword searching on Scopus, Web of Science, and snowball sampling from key papers. The aforementioned topics are chosen for their different insights on the implications of sandscaping, and what the objectives of managing coastal change should be (according to these perspectives). As argued in the introduction (Chapter 1), sandscaping has many attributes of a resilient approach, and Chapter 2 revealed that resilience is a key concept within which the objectives of current coastal policy (for example the current FCERM strategy, (EA (2020))) are framed. Meanwhile, environmental justice can be used to understand the social impacts of a particular coastal management approach, and the adaptation literature reveals how humans respond to and perceive a change to their environment.

3.2 Resilience

This section begins by presenting the definitions of resilience used in this review (section 3.2.1). An overview of socio-ecological systems theory is provided next, outlining the systems framing used in this thesis (3.2.2). Next the review considers different types of resilience, with a particular focus on transformation (3.2.3). Subsequently this section explores how resilience is built or lost, focussing on the concept of adaptive capacity, and how this can be applied to a coastal context (3.2.4). The relationship between resilience, uncertainty and maladaptation is also considered (3.2.5) before ending with a discussion on the criticisms of resilience (3.2.6), and in particular, where the concept may raise tensions with environmental justice.

3.2.1 Defining resilience

There are many different definitions of resilience, and uses of the term across disciplines (Brown, 2014). For example, resilience is applied in engineering, environmental sciences, health, psychology and disaster studies literature, amongst others (Brown, 2014; Matyas and Pelling, 2015). Even within the same field, the definition of resilience can be contested (Twigger-Ross et al., 2015). For example, analysis of climate change research by Bahadur et al., (2011) finds 16 different uses of the term. Although there is relevant theory on resilience, and in particular transformation, from the sustainability transitions literature (IPCC, 2022), this literature review specifically draws upon definitions of resilience from the socio-ecological resilience literature, given that this research takes a systems lens to understanding social and environmental dimensions to coastal change.

The central idea to resilience, is that it is a measure of the ability to withstand and bounce back from shock events (Holling, 1973; Tompkins and Adger, 2004; Adger et al., 2005a). Work by Holling (1996) provides an early and prominent definition of ecological resilience[7], which builds upon concepts from engineering resilience

[7] Ecological resilience is a term used to describe resilience of the natural environment and its associated biophysical process, ecosystems and all species residing within it (Holling, 1996).

theory. As such, in Holling's (ibid) definition, resilience is recovery from a stress event back to an original system state, and the idea of social resilience is not included. Later work by Folke et al., (2005) does incorporate social resilience, (described as the resilience of people at an individual, community or population level) but similarly considers one system state: "*the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks*" (Walker et al., 2004, p.1). Where these definitions of resilience are prescriptive in stating resilience is returning to precisely how the system was before a shock, later definitions are more open as to whether a system can change in certain ways, as long as system functioning is not compromised. This is a key area of evolution amongst the literature, and Figure 3.1 highlights the two proposed theories.

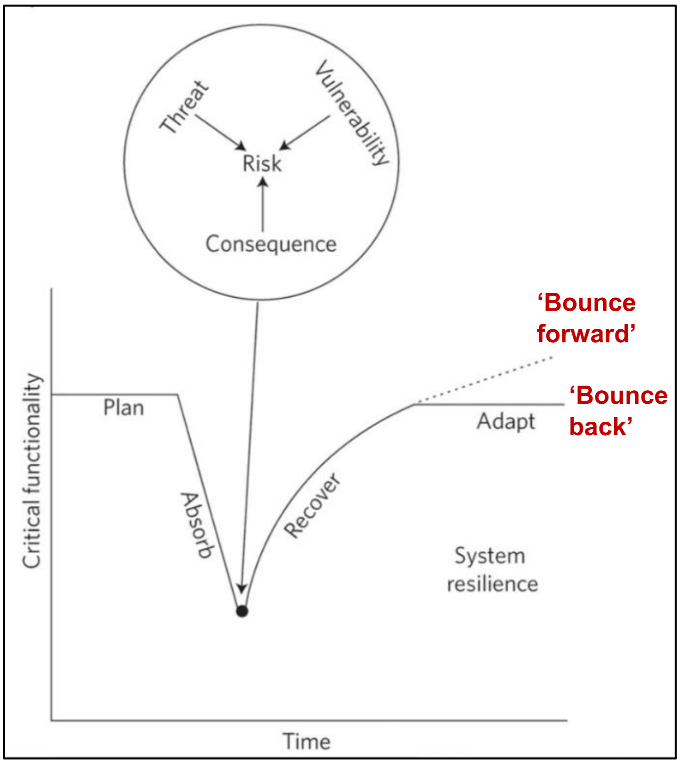


Figure 3.1 Illustration of two different pathways for recovery (bounce back resilience, solid line, and bounce forward resilience, dotted line) (annotated from Townend et al., 2021).

The solid black line on the diagram depicts the system returning to its original state (known as 'bounce back resilience') whereas the dotted line depicts the system entering a new state with a higher level of functionality ('bounce forward resilience'). The latter is a more recent theory (Greg-Lloyd et al., 2013), arguing resilience is the ability to bounce forward and morph into a different state, if the status quo cannot be maintained (Folke, 2006; Eakin et al., 2009; and Rozer and Surminski, 2020). In this regard, Folke (2006) argues, bounce forward resilience can be transformative, if the system has an ability to change in response to pressures. Transformative resilience is discussed further in section 3.2.3. The idea of 'bounce forward' resilience came to fruition by work on social resilience from the social sciences (Bene and Doyen, 2018), and therefore is a particularly relevant concept for analysing social systems. It also reflects an increasing complexity to theories on resilience, where rather than a pre-defined end state or equilibrium, there is the potential for multiple different future system states following a disturbance, each with their own associated resilience (Greg-Lloyd et al., 2013), that might involve learning and adaptation (Cutter, 2016).

This thesis draws upon the more recent definitions of resilience, which principally focus on retaining functionality and the avoidance of harm, and uses two definitions to consider both social and environmental resilience. Environmental resilience is defined in this thesis as "*the larger the shock that the system can put up with and remain "viable" in the long run"* (Bene and Doyen, 2018, p.980). For social resilience, Maclean et al's (2016, p. 523) definition is used, which includes the themes of learning and self-reflection: "*the adaptive and learning capacity of individuals, groups and institutions to self-organise in a way that maintains system function…in response to a disturbance"*. Noteworthy is how Maclean et al., (2016) define resilience using the concept of adaptive capacity, which is also how resilience is defined in the EA's (2020, p.25) FCERM strategy: "*the capacity of* *people and places to plan for, better protect, respond to, and recover from flooding and coastal change*". Adaptive capacity is therefore an important concept in understanding how resilience is built or lost, and is explored in section 3.2.4.

3.2.2. Resilience in socio-ecological systems

Figure 3.2 from Virapongse et al., (2016) illustrates the way in which social and ecological dimensions (left and right circle) influence each other (central circle) within a system. This relationship can be highly interdependent, for example early work by Adger (2000) demonstrates the dependency of societal use of mangrove ecosystem services[8], and the negative societal impacts that stem from mangrove loss. This high dependency between the social and natural world shows the influence of each on the other, and therefore the possibility that change within one part of a system potentially impacts another. Greg-Lloyd et al., (2013) highlight the influence of land use planning and infrastructure development in the UK on increasing the vulnerability of the coastal zone to flooding and erosion. Therefore, an understanding of both social and environmental components, and how they interact, is necessary when assessing the impacts of a coastal policy or intervention. Within socio-ecological systems, resilience may vary between social and ecological components, and across spatial and temporal scales (Maclean et al., 2016). Howarth et al., (2020) argue that a single component within a system, or the entire system itself, has the capacity to cope or recover from a stress event (adaptive capacity). It is therefore important to consider resilience across multiple scales and dimensions within a system.

[8] Goods and services provided by the natural world that is beneficial to society. There are many different types of ecosystem services, from regulating services (e.g. trees producing oxygen) to cultural services (e.g. mental health benefits from spending time outdoors). (UK National Ecosystem Assessment, 2021).

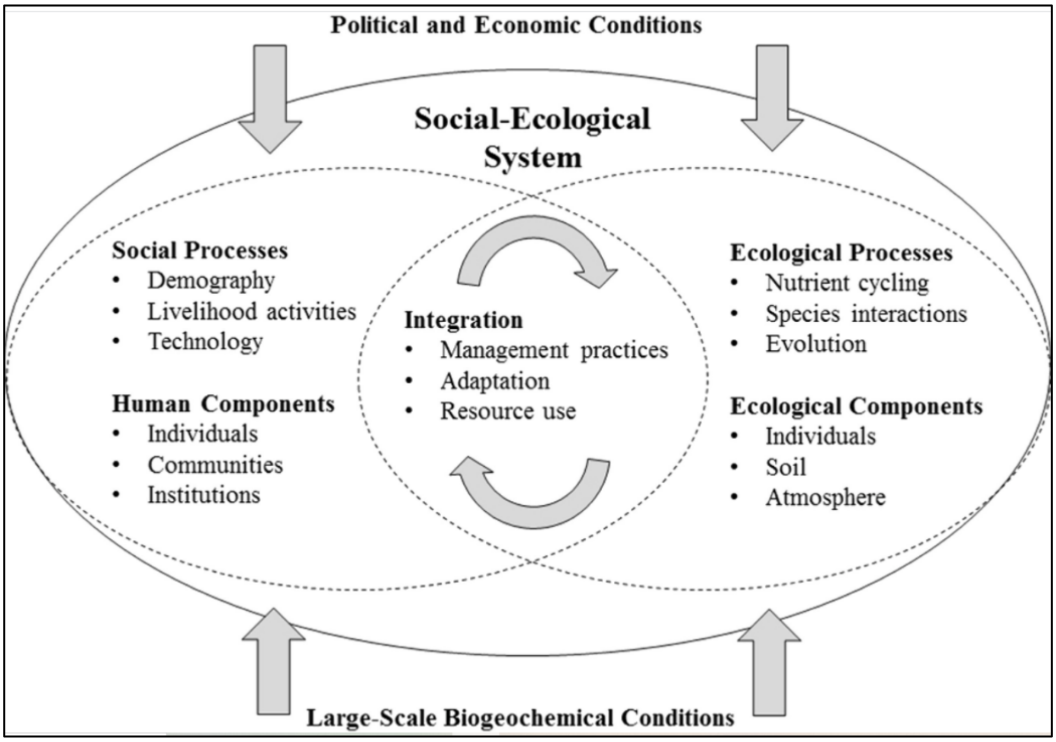


Figure 3.2 Illustration of the linkages between social and ecological processes within a socio-ecological system, from Virapongse et al., (2016).

Although this thesis draws upon socio-ecological systems theory, an environmental, rather than strictly ecological, system is considered. Given that resilience literature evolved from ecological resilience theory, the terminology reflects this, despite much of socio-ecological systems literature using the terms 'environment' and 'ecology' interchangeably (Cote and Nightingale, 2011; Virapongse et al., 2016). Others have stressed that socio-ecological systems theory is not about implying separation of humans from nature, but allowing a focus on the connections between the two (as this research similarly explores) (Davidson-Hunt and Berkes, 2009). Therefore, although this review draws upon socio-ecological systems theory, a broader environmental lens is applied to the thesis. The system examined in this thesis is the interaction between the coast and the coastal residents of Bacton, Walcott and Happisburgh in North Norfolk (as outlined in Chapter 2). Contrary to the ecological processes displayed in Figure 3.2, this thesis solely considers coastal erosion, and explores geomorphological components such as the cliff and beach dynamics of the coast. In terms of social components, this thesis considers the social processes (of individuals, communities, and institutions) living alongside the coast, their relationship to and perceptions of the coast, including how coastal change is managed.

3.2.3 Different 'types' of resilience

It has been suggested that the types of responses to shock events can be considered in terms of the level of resilience associated with that response. This section draws specifically upon the conceptual frameworks of Folke et al., (2010), Matyas and Pelling (2015), Bene and Doyen (2018) and Milhorance et al., (2021), who put forward different types of resilience, that represent different levels of resilience for socio-ecological systems. These authors were chosen for their explicit attention to different 'types' of resilience, considering resilience as a pluralistic concept rather than just one entity (Bene and Doyen, 2018). Furthermore, the authors (ibid) apply their resilience categories either to socio-ecological systems (Folke et al., 2010; Bene and Doyen, 2018) or from a disaster risk management perspective, which is still of relevance to this thesis, as it focuses on the connections and interdependencies between the social and natural world (Matyas and Pelling, 2015; Milhorance et al., 2021). The different categories of resilience presented by the authors are summarised in Table 3.1. The name of each category is presented verbatim in column 2 ('resilience categories'), with analysis of their work in columns 3 and 4.

Table 3.1 Categorisations of resilience within literature (Table: I Cotton).

Authors	Resilience categories	Category descriptions (paraphrased by author)	Relationships between categories
Folke et al., 2010	Resilience Adaptability Transformability	Absorbing and potentially altering, but not beyond the parameters of the same system state. The ability to learn or alter responses, within the same system state. Deep rooted change that shifts into another system state.	There is not one category a system can be in, and over time different categories can be occupied. Resilience is periods of persistence, interrupted by sudden or slow onset adjustment or transformational change, before the dormant resilience period begins again.
Matyas and Pelling, 2015	Resistance Incremental adjustment Transformation	Not described in paper. Temporary change, returning to the original system state. Surface level, rather than superficial, change. Challenging the way social systems operate. The structure and functioning of the system has changed so much to the effect that it can now be considered a different system.	An approach could aim for resistance in the short-term and more drastic change in the long-term. Multiple system responses can occur at one time. E.g. resistance could happen at one part of the system and transformation at another, within the overall system.
Bene, and Doyen, 2018	Resistance Absorptive capacity Incremental adaptation Adaptive preference Transformation	Withstanding or deflecting a shock or stress in the same system state. The maximum amount of stress a system can take (persist) while maintaining structure, functioning, and the same system state. Adaptive capacity, learning, and enacting change from that learning. Altering perceptions by coping with a shock. New system created through significantly different structure and functioning.	The five responses sit on a continuum, rather than strict categories. They can overlap and are not mutually exclusive.
Milhorance et al., 2021	Persistence	Living with the shock, returning to the original system state.	The authors justify the use of three categories, given that

	Incremental adjustment Transformational response	Ability to learn and do things differently, the changing actions result in a slightly different system. The system has changed significantly by actions enacted.	it has been argued in literature there is considerable overlap in the five response model developed by Bene and Doyen (2018).

As can be seen in Table 3.1, there is considerable overlap in the resilience categories presented by the authors (ibid), with similar incremental depths of change, and yet each author adopts slightly different terminology. For example, where Folke et al's., (ibid) earlier paper refers to simply 'resilience' as a first category, other authors refer to 'resistance' (Matyas and Pelling, 2015; Bene and Doyen, 2018) or 'persistence' (Milhorance et al., 2021). This choice reflects the evolution of the concept of resilience in literature beyond a bounce back definition, as discussed in section 3.2.1. All frameworks include both bounce back and bounce forward types of resilience, and all authors argue that resilience increases from one category to the next. Furthermore, all authors agree that categories are interchangeable, not mutually exclusive, and that a system can transition between categories (Folke et al., 2010; Bene and Doyen, 2018) or have multiple system responses at the same time (Bene and Doyen, 2018). It is important to note that similarity between the frameworks partially reflects the fact that authors draw upon each other's work. Both Matyas and Pelling (2015) and Milhorance et al., (2021) draw upon the work on Bene (citing for example Bene et al., 2013 and Bene et al., 2015; 2018, respectively), and Milhorance et al., (ibid) also cites the work of Folke et al., (2010) in developing their own framework.

Differences in terminology between the authors can also be seen with the median categories of resilience ('adaptability', 'incremental adjustment' and 'incremental adaptation' are all used). This reflects a contrast within literature on whether the extent of system change in this category results in the same, or a slightly altered, system state. While all authors bar Milhorance et al., (2021) argue it involves the same system state, Folke et al., (2010, p.1) argues adaptability is change within a greater "*stability domain or basin of attraction*". Overall, differences in terminology are due to differences in scale and framing of the wider socio-ecological system state by each author. While further comparative analysis could be taken on the different types of resilience presented by different frameworks in literature, this is beyond the focus of resilience within this thesis, which is principally concerned with the concept of transformation. Therefore, the last type of resilience presented by the authors, 'transformation', is discussed next in greater detail.

As seen in Table 3.1, whereas categories with lower resilience relate to withstanding shocks without introducing any change to the system (e.g. 'resistance' or 'coping'), or altering part of a system, but not fundamentally so (e.g. 'incremental adaptation'), 'transformation' is framed as a change that significantly alters the structure and functioning of a system, so that effectively a different system has been created. The new system has significant length (i.e. permanence) and depth (i.e. deep-rooted) of change. This concept of transformation appears highly relevant to the definition of social resilience by Maclean et al., (2016), adopted by this thesis (section 3.2.1), so long as system functioning is retained (a key element of the definition). All of the authors in Table 3.1 argue transformation has the highest level of resilience, and of all the types of resilience, 'transformation' has the greatest agreement amongst the different frameworks. Bene and Doyen (ibid) argue resilience categories can be best understood as a continuum or scale, with 'transformation' at the top of that scale. However, this suggests an inherent assumption within the literature, that because 'transformation' provides the greatest opportunity for a system to change, it also provides the greatest opportunity to build resilience. Kates et al., (2012) similarly refer to the change from transformation as innovative, large-scale, and significantly altering system structure and functioning. However, by this logic, transformational responses provide the greatest opportunity for both desirable and undesirable change.

Undesirable change is referred to in literature as 'maladaptation', which is associated with a reduction in resilience (Milhorance et al., 2021), and is a key concept linking the resilience and adaptation literature (maladaptation is also explored in section 3.4.1). There is therefore disagreement within the resilience literature on the relationship between transformation and maladaptation, simultaneously presenting transformation as the most desirable system response (Milhorance et al., 2021) and also a response with the greatest likelihood of maladaptation, given the amount of change that is being introduced to a system (Matyas and Pelling, 2015). This has led to attention on the different causes of transformation, with recent work highlighting that transformation can be 'deliberate' or 'forced' (IPCC, 2022). Deliberate transformation is presented as the more desirable, and more likely to lead to desired adaptation goals and higher resilience, whereas forced transformation may have unintended consequences (i.e. maladaptation) (Folke et al., 2010; IPCC, 2022).

In their definition of transformation, Folke et al., (2010, p.6) argue: "*transformations consist of three phases: being prepared or even preparing the social-ecological systems for change, navigating the transition by making use of a crisis as a window of opportunity for change, and building resilience of the new social-ecological regime*". In this definition, it is implied that having 'preparation time' with deliberate transformation leads to greater resilience. The above findings demonstrate there is a need for further empirical analysis on transformation, and its impact on overall system resilience and maladaptation. Furthermore, the conceptual frameworks analysed in Table 3.1 focus on categorising resilience of an overall system, and there is less analysis by the authors on how individual components within a system can build resilience (with the exception of Milhorance et al., 2021, who apply their conceptual framework to consider the impact of drought for households in Brazil). There is therefore also a need for research that critically analyses resilience at different scales within a system.

Applying this theory on transformation to a coastal change context, both sandscaping and adaptation options under a managed realignment policy scenario could be viewed as examples of transformative coastal change. Sandscaping has dramatically increased the height and volume of Bacton and Walcott beach (Johnson et al., 2020b), and arguably fits all three of Kates et al's., (2012) categories of transformational adaptation, in that it is innovative, large-scale (although by how much is not quantified in the paper), and significantly alters the geomorphological (and thus very likely the ecological) structure and functioning of the coastline. Meanwhile, adaptation options for managed realignment, such as property rollback, the closure and opening of old/new economies (and its impact on livelihoods), and demolition of coastal towns and relocation, are regarded in literature as transformative policies to deal with coastal risk (O'Brien, 2017; Coastal Partnership East, 2019; Haasnoot et al., 2021). Such policies reflect Folke et al's., (2010, p.5) definition of transformational change (covering similar themes to Bene and Doyen's (2018) in Table 3.1): "*shifts in perception and meaning, social network configurations, patterns of interactions among actors including leadership and political and power relations, and associated organizational and institutional arrangements*". This definition mirrors the future reality that some coastal communities face in moving, rebuilding, and potentially rearranging infrastructure and social networks away from their current location. The emphasis of changing social perceptions within Folke et al's (ibid) definition also highlights the role of perceptions (explored further in 3.4.3) in building social resilience. This research seeks to critically analyse the transformative nature of sandscaping, and managed realignment, in further detail, and implications for coastal resilience.

3.2.4 How is resilience gained or reduced?

If resilience can be understood as a plural concept, with multiple types each with their own level of system change – how is resilience built, maintained, and lost? The frameworks presented in Table 3.1 argue that responses with greater resilience draw upon a greater number of adaptive capacities. For example, the "*ability to adapt*" (Matyas and Pelling, 2015, p.7) "*adjust responses*" (Folke et al., 2010, p.1), or make "*proactive and informed decisions*" (Milhorance et al., 2021, p.679). This highlights the importance of 'capacity' as a concept to measure resilience change. The literature presents three main capacities of relevance to building resilience; 'capacity to prepare', 'capacity to recover', and 'capacity to adapt' (Oriangi et al., 2020) (although there is variation, with other authors using 'capacity to adapt', or adaptive capacity, as an umbrella or all-encompassing term (Cinner and Barnes, 2019)). The use of a capacities framing stems from a US Army Corps definition of resilience (Townend et al., 2021), and is widely utilised in disaster studies literature (Oriangi et al., 2020).

'Capacity to prepare' refers to an ability to anticipate and lessen the impact of a shock (Oriangi et al., 2020). Factors found to contribute towards a 'capacity to prepare' include knowledge, awareness and risk perception of a shock (Lwin et al., 2020; Alizadeh and Sharifi, 2021) alongside previous experience (Lwin et al., 2020) and agency (Cinner and Barnes, 2019). Meanwhile, 'capacity to recover' refers to an ability to live alongside a shock or stress event (Oriangi et al., 2020). Factors found to enable recovery include heterogeneity (i.e., resource availability), flexibility (e.g., of livelihoods), and access to social support networks (Tompkins and Adger, 2004; Lwin et al., 2020; Alizadeh and Sharifi, 2021). The last capacity of relevance, 'capacity to adapt', refers to an ability to move or change in response to a shock. Factors found to enable or constrain adaptive capacity include the strength of connection to place (sense of place is explored further in section 3.4.3) and relationships with others (such as community cohesion and trust in institutions) (Adger et al., 2005a; Lwin et al., 2020; Alizadeh and Sharifi, 2021). Figure 3.3 summarises the range of factors highlighted in the literature that enable or constrain the three different relevant adaptive capacities to building resilience.

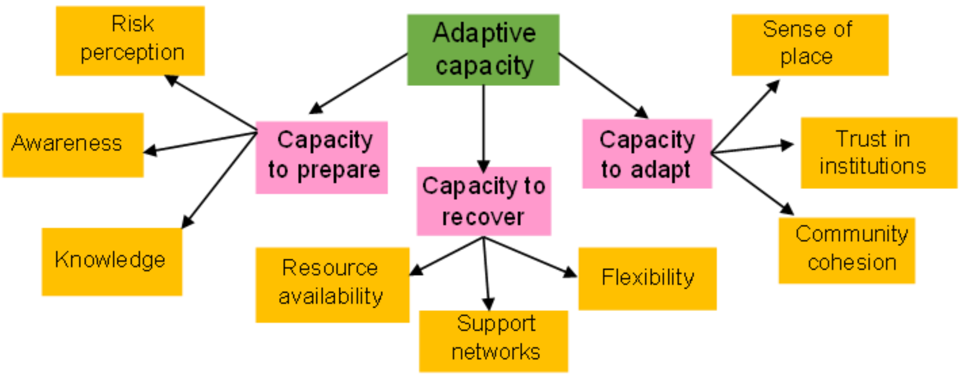


Figure 3.3 Summary diagram illustrating the factors that enable or constrain (individual/ community) adaptive capacity as found in this literature review (Figure: I Cotton).

Applying the concepts 'capacity to prepare', 'capacity to recover' and 'capacity to adapt' to a coastal context, increases or decreases of sediment (and sufficient sediment within a coastal system), and normal functioning of natural geomorphological processes such as longshore drift, are important factors contributing to the capacity to recover and withstand shocks from coastal erosion events (Hall et al., (2015). Another enabler of recovery capacity, for physical or environmental resilience, is heterogeneity, in terms of a diversity of species within a coastal system (Adger et al., 2005a). Heterogeneity facilitates resilience where there is more likely to be differential impact to external shocks within a system

(Adger et al., 2005a). This entails the structure and functioning of ecosystems is less likely to be depleted, and therefore the system is more likely to have a higher capacity to recover following a disturbance.

Turning to social resilience, the EA's FCERM strategy (2020) describes some of the actions that will be necessary for coastal communities to adapt to rising erosion risk. These include: "*facilitating community engagement, finding alternative housing for those at risk and in some cases supporting businesses to find opportunities in neighbouring areas",* and subsequently (p.58): "*address safety and access challenges, while 'roll back' policy is still in operation*" (EA, 2020, p.57). A focus on planning for the future is also present in the latest IPCC (2022) assessment report, where the objective of adaptation is defined in terms of capacity building, and in particular, "*the capacity to anticipate and respond successfully to change*" (IPCC, 2022, p.72). The above actions appear to focus on a framing of resilience as having the capacity to prepare for erosion events. However, many of the factors which build 'capacity to recover' and 'capacity to adapt', as shown in Figure 3.3, are equally argued as relevant for building social resilience. For example, Cinner and Barnes (2019) report an individual's capacity to learn and organise, flexibility and access to resources (capacity to recover factors) all increase resilience, meanwhile Tompkins and Adger (2004) found a diversity of social networks (capacity to recover and adapt factors) are beneficial for local communities whilst living alongside coastal change. Therefore, from a social resilience perspective, it appears there is currently greater policy attention to factors that support a capacity to prepare for coastal change, despite the relevance of factors that support the capacity to recover or adapt.

3.2.5 Resilience and uncertainty

It is stressed both within peer-reviewed literature, grey literature, and policy documents that it takes time to build social and environmental resilience to coastal change (Mott MacDonald, 2014; EA, 2020; Day, 2020; Townend et al., 2021). However, this length of time is not specified, nor how it might vary from a geomorphological to a social perspective. This gap links to opposing arguments within literature and policy on whether resilient systems are inherently more uncertain (as advocated by Folke, 2006 and Bellamy, 2019). For example, the EA's (2020) FCERM strategy advocates that, by moving from reactive to more anticipatory adaptation measures, coastal management can become more resilient by being more ready to respond to flood or erosion events, which in turn reduces uncertainty. Leach (2008) however, argues that a resilient approach, in terms of being flexible for a range of long-term outcomes, demonstrates robustness but not necessarily reduced uncertainty. Meanwhile Bahadur et al., (2013) argue that an ability to deal with uncertainty is an attribute of being socially resilient to environmental change.

As highlighted previously in section 3.2.3, transformative resilient approaches can be both accidental and intentional (i.e. 'forced' or 'deliberate'), of which the former has higher associated uncertainty (IPCC, 2022). This raises an interesting question; do coastal management approaches focussed on increasing resilience also increase uncertainty, and where or how is this uncertainty felt in a system? The lived experience of uncertainty in relation to coastal change is not discussed explicitly in the EA's FCERM (2020) strategy, which acknowledges the economic cost of mental health impacts from flooding or erosion, but provides no indication of how communities can be supported to live alongside such uncertainty of coastal risk. Indeed, many criticisms of resilience stem from the practical challenges of operationalising the concept, which is discussed next.

3.2.6 Criticisms of resilience

Several criticisms have been raised regarding the concept of resilience, many of which relate to its practical application. Resilience is often framed as an end goal or an aspiration, with an absence of concrete operational understanding (Brown, 2014; Bene and Doyen, 2018; Townend et al., 2021). In other words, it is often not clear how resilience, and progress towards it, can be measured, particularly for social dimensions (Cutter, 2016). Compounding this, the way resilience is defined and the parameters used to demonstrate it are varied, and selection choice shapes how resilience is perceived and understood (Cutter, 2016; Ensor et al., 2021). This is notwithstanding the potential inaccuracies of using an indicator to measure resilience, when the use of proxies is not an exact measurement of what it seeks to represent (Ensor et al., 2021). Greg-Lloyd et al., (2013) highlights how key concepts frequently discussed in resilience literature, such as adaptive capacity, resilience, and vulnerability, have different definitions depending on which branch of science or social science is considered.

The significance of this ambiguity, is that the objectives of resilience, and its intended recipients are unclear, or can be contested (Cutter, 2016). Some uses of resilience can therefore be normative, and will mean different things to different people with different priorities (Ensor et al., 2021). Further to this, Brown (2014) argues it is not typically specified 'who' and 'what' is building resilience, and in order to operationalise the concept, this needs to be made explicit (Townend et al., 2021). This is despite the limitations of resilience, in potentially causing disproportionate impacts on society, being well argued in literature (Leach, 2008; Eakin et al., 2009; Brown, 2012; Matyas and Pelling, 2015). Despite the policy attention afforded to resilience, the concept has been criticised for being blind to scale sensitivities (Brown, 2013; Matin et al., 2018). For example, research by

Lau et al., (2021) in Papua New Guinea found temporal trade-offs between ensuring community members could fish and self-sustain versus developing the healthy functioning of the ecosystem in the long-term and recovering stocks. This highlights the sensitivity of scale in pursuing resilience, and between social and environmental components of a socio-environmental system. This is therefore further evidence of a research gap in understanding scale-sensitive trade-offs of resilience.

Beyond issues of practical applicability, the ambiguous and subjective use of resilience in socio-environmental systems means some parts over others may be prioritised to promote (specific and potentially limited) resilience (Matyas and Pelling, 2015). Parts, rather than the whole, of a socio-ecological system builds resilience at any one time, and what elements are prioritised is a political choice (Matyas and Pelling, 2015). Resilience, argues Hayward (2013), is also a concept absent of political ecology questions on the causes of environmental damage or social inequality (as seen in the EA's FCERM (2020) strategy). Further, by not sufficiently capturing the unequal distribution of power and resources in society, Matin et al., (2018) argue resilient approaches put forward are by those not vulnerable or marginalised, calling into question issues of participative justice. The reduction of unevenly distributed policy consequences is a growing area of research examining what is termed 'inclusive', 'equitable' or 'just' resilience (Meerow et al., 2019). For example, Matin et al., (2018, p.203) define equitable resilience "*as one which takes into account issues of power, subjection, and resistance; makes visible socially constructed limitations faced by groups and communities at all levels; and thinks about these issues in a joined-up way to avoid unsustainable interventions being made in the name of either disaster response or development*". This focus on issues of equity in following resilient approaches can be explored using the framings of environmental justice literature, and is the next subject of this review. The environmental justice lens of this thesis can indicate where, when and by whom positive and negative impacts are felt, which, as Leichenko and O'Brien (2019, p.183) describe, can help in "*building equity into resilience*".

3.3 Environmental justice

This section firstly introduces the field of environmental justice (3.3.1), before focusing on the three main themes of justice (distribution, participation and recognition) (3.3.2). The causes of environmental justice issues is reviewed next (3.3.3), with a particular focus on a UK coastal policy context. Lastly, this section considers how a plurality of scales can help analyse environmental justice issues in coastal management (3.3.4).

3.3.1 Environmental justice: definitions, origins and development

Environmental justice can be described as both a grassroots activist movement and an academic field of study, concerned with the differential experiences of environmental change on different societal groups (Coolsaet, 2020). It emerged in the United States in the 1980s amid growing realisation that non-white communities were disproportionately affected by environmental harms, for example by living closer to chemical waste plants and suffering lower levels of air quality (Bullard, 1990). However, research has identified other origins of the field, from other communities and other points in time (Murdock, 2020). While first focussing on the differential experiences societal groups face (distributional justice) (Kaswan, 2020), the field has expanded to consider the ability of individuals, particularly marginalised groups, to participate in environmental decision-making (participatory justice) (Marion Suiseeya, 2020) and the extent to which individuals are accepted as a legitimate voice for environmental concerns (recognition) (Coolsaet and Néron, 2020). Distribution, participation, and recognition reflect the three main and commonly referred to branches of environmental justice (Murdock, 2020).

The field of environmental justice has evolved considerably over the last few decades. Notable transitions include an increasing recognition of capabilities (i.e. rights and requirements to a healthy and satisfied life), and not just equity (i.e. uneven impacts across society) (Schlosberg, 2013), which reflects the expansion of the field away from solely considering distributional justice issues. Furthermore, research has widened from distinct spatial contexts to consider global issues such as climate change (leading to the field of climate justice), resource depletion, and the degrowth movement (leading to the field of just transitions) (Schlosberg, 2013; Schlosberg, 2020). In particular, there is a large body of literature examining the ethics and justice of global climate mitigation, in terms of the allocation of rights and responsibilities (Adger et al., 2011; Dryzek, 2013) and climate change governance (Dryzek and Tanasoca, 2021).

The application of environmental justice to climate adaptation, however, has been much less studied (Edwards, 2020), and is a research gap this thesis contributes to. Furthermore, much of the environmental justice literature focusses on international contexts. While the concept has been applied to the UK to consider different social inequalities and deprivation, including the differing socio-spatial experiences of flooding (Walker, 2009; Walker and Burningham, 2011; Fernandes-Bilbao et al., 2011; Sayers et al., 2017), urban air quality (Walker et al., 2005; Dietz and Atkinson, 2007; Briggs et al., 2008; Mitchell et al., 2015), and coastal management (Cooper and McKenna, 2008; Eakin et al., 2009; Thaler et al., 2017), there is less research in the UK more recently on coastal change and managed realignment, and not in the context of sandscaping. Particularly in a UK context, the term ‘environmental justice’ may be used interchangeably with ‘social justice’ or ‘social equity’, and use a social disadvantage or social vulnerability framing to explore the unequal impact of environmental issues (for example Walker and Burningham, 2011; Preston et al., 2014; Sayers et al., 2018).

3.3.2 The different themes of environmental justice

As mentioned in 3.3.1, environmental justice can be broken down into three main concepts or ‘issues’: distribution, participation, and recognition. Distributive justice can be defined as “*how harms and benefits are distributed and experienced*” (Kaswan, 2020, p.22), and was first conceptualised as the experiences different societal groups face to environmental harms (Bullard, 1990; Blais, 1996). Such experiences (hereafter impacts), are typically framed as ‘physical harm’ from environmental conditions or ‘stigmatic harm’ associated with certain neighbourhoods (Kaswan, 2020, p.29). Distributional justice initially focused on the spatial configuration of where impacts are felt (Holifield et al., 2009), but more recent research has stressed the relevance of temporal dimensions to impacts (Pellow, 2020; Bopp and Bercht, 2021) as delays to when impacts materialise, and linked to questions of intergenerational justice.

There is no clear definition of how distributional justice or injustice can be measured, which is subject to debate in literature (Kaswan, 2020). Several authors argue the concepts of ‘equality’, ‘fairness’ and ‘justice’ are used interchangeably (see for example Ikeme, 2003; Johnson et al., 2007), despite having different philosophical foundations in egalitarianism (Rawls, 1971), utilitarianism (Arthur and Shaw, 1978) and capabilities (Sen, 2009). Therefore, depending on which philosophical foundation of justice is put forward, the concepts of ‘equality’, ‘fairness’ and ‘justice’ are subjective and hard to measure (Thaler et al., 2017). For example, ‘fairness’ for the greatest number of people may look differently to ‘fairness’ for the most vulnerable within society (Johnson et al., 2007), and equity in benefits and experiences may look differently to supporting the most vulnerable communities (Tyler, 2000). Consequently, it is important for a plurality of perspectives of distributional justice to be considered in coastal decision-making, recognising potentially different philosophical foundations.

The second key issue within environmental justice is participation, which is concerned with the degree to which all relevant stakeholders are included in decision-making (Marion Suiseeya, 2020). Stakeholders may not be consulted before a policy is introduced, or participation may be tokenistic rather than offering the opportunity for a particular group to meaningfully engage and contribute their views (Bell and Carrick, 2017). Participatory justice issues can also be caused by imbalances of power, where some voices are heard and respected to a greater extent than others (reflecting power imbalances both within and between different stakeholder groups) (Marion Suiseeya, 2020, Rodriguez and Inturias, 2018). Within the wider environmental justice field, and globally, there is ample research on the exclusion of minority or indigenous groups in the management of natural resources (for example Anguelovski and Corbera, 2023; Diep et al., 2022; Makey et al., 2022; Palmer et al., 2022; Reyes-Garcia et al., 2019). A key area of agreement in the participatory justice literature is the need for co-governance of natural resources, that involves all the relevant stakeholders from the outset, and where all stakeholders are involved in the design and implementation of a policy or project (Diep et al., 2022; Marion Suiseeya, 2020; Palmer et al., 2022; Reyes-Garcia et al., 2019; Rodriguez and Inturias, 2018).

Participatory justice links closely to recognition, which considers whether all communities affected by a policy or environmental harm have been considered in policy making. When impacts are being considered, recognition asks questions of otherness, reciprocal recognition, respect, and identity (Coolsaet and Neron, 2020). This could be in terms of whether a policy has considered different values or knowledge systems (the idea of epistemic justice, Miriti et al., 2022, Makey et al., 2022, Palmer et al, 2022), and ways of living for certain stakeholders, such as indigenous communities (Rodriguez and Inturias, 2018). Fraser and Honneth (2003) argue that if certain individuals are being disproportionately impacted within a population, this is the result of not being sufficiently valued, and a form of recognitional injustice. If individuals are impacted by a policy or harm where they weren't originally considered, Taylor (1994) argues this is another form of injustice, where being initially overlooked is a form of misrecognition. Although the three branches of environmental justice have typically been used in literature to separately analyse different injustices (for example economic issues with distributional justice, and cultural issues with recognition) (Coolsaet and Neron, 2020), considering both in tandem can provide a deeper analysis of environmental justice issues, and is applied here in the context of coastal management.

3.3.3 What causes environmental justice issues?

There are many reasons why an individual, and certain societal groups, are more impacted by environmental harms, which reflects both intrinsic (e.g. personal characteristics) and extrinsic factors (e.g. societal structures and actions). While age, gender, mental and physical fitness are all found to increase an individual's vulnerability to environmental harms (Bevacqua et al., 2018; Rizzo et al., 2020), early environmental justice work in the 1980s highlighted how communities most affected by an environmental issue reflected historical patterns of inequality (for example in the United States, housing demographics reflect economic income and historical patterns of racial segregation (Kaswan, 2020)). Income is widely argued to be a key determinant (Atteridge and Remling, 2018; Warner and Kuzdas, 2016;

Vasseur, 2021), where poorer residents have less resources at their disposal to buffer effects following an environmental harm, or may live in neighbourhoods less likely to be protected, or more likely to be displaced, by an environmental policy (Anguelovski et al., 2016). Indeed, the relative affluence or deprivation of an area (Cutter and Corendea, 2013) and related socioeconomic factors, is argued to affect an individuals' access to assets, services, skills and resources (Blaikie et al., 2005; Bevacqua et al., 2018; Rizzo et al., 2020). In this regard, justice issues can be seen from a political economy perspective, influenced by the distribution of power and capital.

Social determinants of vulnerability may intersect with physical climate vulnerability, where certain neighbourhoods have greater inherent vulnerability due to geography and climate variables (Ensor et al., 2021). In the UK, there has been considerable research exploring 'natural' and 'imposed' injustices to flood risk (Johnson et al., 2007; Walker, 2009) or climate change in general (Preston et al., 2014), highlighting 'multiple injustices' where high flood risk areas correlate with low income, low property price neighbourhoods (Rozer and Surminski, 2020). While there is broad research on the determinants of environmental justice issues both in the UK and globally, this review focuses on the impact of defended and undefended coastlines, given the case study context of the research. As highlighted in section 2.2.2, the unequal allocation of public funding for coastal management raises justice issues, where some areas of England's coastline are protected and some are not (or areas are protected to differing future timescales). Funding for coastal management in the UK requires a sufficient cost-benefit ratio to approve spend on schemes (Defra, 2021) (funding sources for coastal management are outlined in section 2.2.2). Schemes are therefore awarded according to a utilitarian logic (the greatest good versus money spent) rather than in areas of high priority or vulnerability (Johnson et al., 2007).

From an egalitarian perspective, this can be viewed as unjust (Rawls, 1971). Such a formula discriminates against sparsely populated areas and assets that can't be monetised, where it is more difficult to demonstrate a sufficient cost-benefit ratio (EFRA Committee, 2019). For example in Cornwall, many areas of coastline require funding to adhere to the Cornwall and Isles and Scilly SMP, but in reality, only areas with bids that demonstrate multiple or co-benefits will be recipients of funding (EFRA Committee, 2019). A high profile example is the City of London, which receives significant funding for flood defences and flood protection than more sparsely populated parts of the Lower Thames (Johnson et al., 2007). And in this thesis' case study area, the villages of Bacton and Walcott (high coastal erosion risk) are expected to receive multi-decadal protection from coastal erosion, and greater per capital spend, because of their close proximity to the nationally important Bacton Gas Terminal. Although parts of Europe follow a different policy logic (see 2.2.2), the United States (Louisiana) similarly allocates coastal defences in their 50-year Coastal Master Plan to areas with the greatest benefit per number of residents according to cost spent, rather than areas of highest physical or social vulnerability, and not all communities are protected (Hemmerling et al., 2019).

Differing levels of coastal protection lead to an uneven distribution of impacts from coastal erosion or flooding. Impacts include losing property or infrastructure to the sea (as has already occurred in Happisburgh, see section 2.4.2) (Frew, 2012), and disproportionately lower property prices, which can lead to economic impacts and demographic changes, such as a rise in second home ownership (Nicholson-Cole and O'Riordan, 2009). Analysis by Rozer and Surminski (2020) on property in flood risk areas argues that parts of England and Wales are at risk of mass migration out, and blight (economic decline and stigmatisation) of a local area, where many are unable to pay for insurance or get a mortgage. Clean-up after storm events and the long-term impact of blight can therefore cause sustained financial loss for certain areas (Coastal Partnership East, 2019). Asides from economic impacts, storm events can cause ongoing mental health impacts, stress and trauma for local residents (Day, 2020).

3.3.4 Scales in environmental justice

Returning to the environmental justice literature at large, research typically assigns impacts to society in a binary way, for example at a national versus local level (Cooper and McKenna, 2008) or between ‘haves’ and ‘have nots’; ‘winners’ or ‘losers’ (Walker and Burningham, 2011; Thaler et al., 2017; Ensor et al., 2021). However, a scale-sensitive lens is of relevance in coastal management, where there may be different social perspectives and different ‘trade-offs’ depending on a particular scale. For example, Cooper and McKenna (2008) highlight that it is more difficult to justify the allocation of public funding for local level coastal defences, if the issue is considered at a national level, in terms of a funding contribution for all citizens. Furthermore, Chapter 1 highlighted that climate change impacts will intensify into the future, making more and more coastal areas vulnerable (Sayers et al., 2022). Therefore, a wider temporal perspective may also make it harder to justify funding. Consequently, there are trade-offs according to scale in coastal management between social and ecological components, and across spatial and temporal scales (Cooper and McKenna, 2008; Walker and Burningham, 2011; Bopp and Berch, 2021). Figure 3.4 illustrates the different scales and perspectives of relevance.

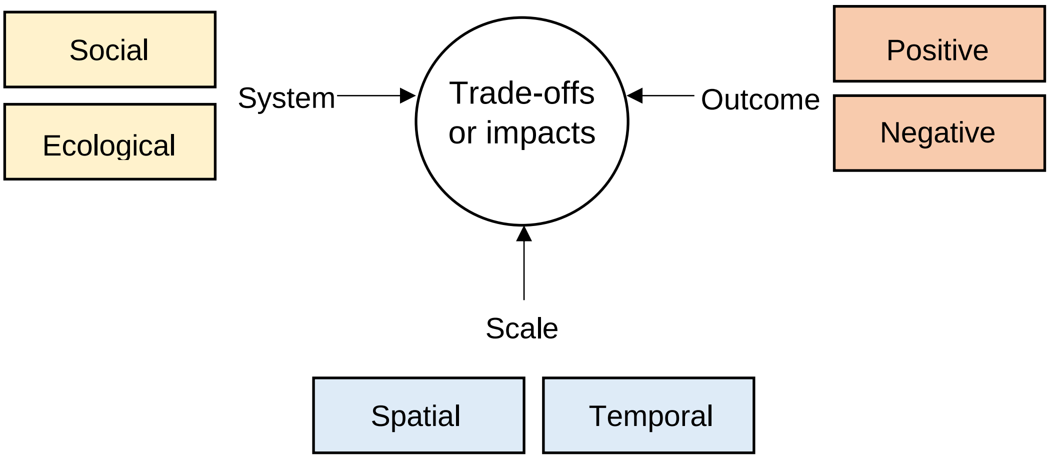


Figure 3.4 Trade-offs in coastal management, between different outcomes (red), different parts of the system (yellow) and different scales (blue). Figure 3.4 is a summary illustration of the literature reviewed in this section (Figure: I Cotton).

Figure 3.4 highlights there are many dimensions to an environmental policy or harm that interact. For example, coastal communities could experience positive impacts from coastal erosion policies in the present day, and negative impacts in the future (or vice versa and/or concurrently). It is therefore important to consider positive and negative social and environmental impacts across time and space. While previous literature states some societal groups are impacted by resilience or adaptation strategies, it is often not elaborated how impacts might vary over time or lead to knock-on impacts (Anguelovski et al., 2016). Furthermore, identification of spatial or temporal impacts is but a first step; how impacts are experienced, in an in-depth local context, is also vital for a more nuanced understanding of environmental justice (Bopp and Bercht, 2021). Recent empirical, local-scale research has taken place in international contexts, for example coastal communities in Norway and India (Bopp and Berch, 2021) and in the United States (Hemmerling et al., 2019), but not applied to date in a UK context, and specifically not in the context of sandscaping. The next section of this review turns to adaptation, the third and final concept of relevance in this research.

3.4 Adaptation

This section begins by defining adaptation and exploring its links between the resilience and environmental justice literature (3.4.1). Next this section considers how adaptation can be evaluated, exploring the theme of adaptation 'effectiveness' (3.4.2). Section 3.4 subsequently focuses on community perceptions of adaptation, and includes a review of factors that influence public perceptions of adaptation in the present-day (3.4.3) and of future coastal change (3.4.4), given that understanding and preparing for future coastal change is a key policy gap (CCC, 2018: 2021) (as highlighted in Chapter 1).

3.4.1 Defining adaptation

Adaptation is the term used to describe how we respond (i.e. the actions we take) to a change in environmental conditions, and is commonly applied in the context of climate change (IPCC, 2014). It is defined by the IPCC (ibid, p.5) as "*the process of adjustment to actual or expected climate and its effects*". Tompkins et al., (2010) similarly frame adaptation as a process rather than an endpoint, and argue adaptation is dynamic, iterative and cyclical. It can take place at multiple scales, be it at an individual, collective or institutional level, and can be indirect, e.g. that serve to build adaptive capacity (the means to adapt, section 3.2.4), or direct, for example an adaptation action in itself (Tompkins et al., 2010). While the concept of adaptation is used outside of climate change literature and climate change is but one of numerous causes of stresses in socio-ecological coastal systems, this section largely draws upon such literature, given climate change is argued to be the principle driver intensifying shock events for England's coasts this century (EA, 2020). Secondly, while adaptation can be considered in an environmental sense, in terms of how other species utilise, exploit or adapt to new conditions (Cooper and Pile, 2014), given this thesis solely explores environmental resilience in terms of geomorphological changes, this review is also bounded in scope to solely consider human, rather than ecological, adaptation.

Considerable crossover can be observed between the concept of adaptation and both resilience and environmental justice. The EA's (2020) FCERM strategy frames resilience as an integral part of adaptation, where the end goal of adaptation should be increased resilience. This can be seen in the strategy's definition of adaptation (described as being "*climate ready*" EA, ibid, p.25): "*changing our lifestyles, economy, infrastructure and local places to make us more resilient and adaptable to future consequences*" (EA, ibid, p.22). Furthermore, section 3.2.3 revealed that there are different types of adaptation responses within a system (for example 'incremental adaptation' and 'transformative adaptation', see Table 3.1), which vary in terms of their level of resilience and depth of change bought to a system (Cooper and Pile, 2014). Adaptation strategies can therefore be understood in terms of differing levels of resilience.

Meanwhile, crossover can be observed between the adaptation and environmental justice literature, with many adaptation frameworks including considerations of justice. For example, the IPCC's (2022, p.49) latest assessment report argues adaptation should be "*effective, feasible, and conforms to the principles of justice*". This is the first time that equity and justice have so closely been embedded in the IPCC's conceptualization of adaptation, where the previous (fifth) assessment report (IPCC, 2014) focused on metrics of vulnerability and resilience. In Adger et al's (2005b) highly adopted framework for successful adaptation, equity is one of four key principles (alongside effectiveness, efficiency and legitimacy), and social justice is one of eight pillars in Nicholson-Cole and O'Riordan's (2009) framework for successful coastal governance in Norfolk.

A key area where all three fields intersect can be seen with the concept of maladaptation, which can be defined (using Barnett and O'Neill's widely used definition, 2010, p.211) as "*action taken ostensibly to avoid or reduce vulnerability to climate change that impacts adversely on or increases the vulnerability of other systems, sectors or social groups*". Therefore, maladaptation refers to adaptation that has either not achieved its objective, or inadvertently caused negative side effects. This links to the environmental justice literature in where, when and whom experiences maladaptation. Leichenko and O'Brien (2019) argue that adaptation measures set with the goal of building resilience can reduce the risk of maladaptation, because the dual focus of resilience on both recovery/capacity building and risk reduction provides multiple co-benefits, citing for example the mitigation and adaptation co-benefits of utilising green infrastructure such as tree planting. However, whether resilience increases or decreases the risk of maladaptation is a key area of debate in the literature, highlighted in section 3.2.3, in the context of transformation.

More recently in the adaptation and resilience literature, there have been calls for 'just' adaptation, that upholds rights and identifies responsibilities for each societal group (Byskov et al., 2019). The term 'just resilience' has also be used in European Environment Agency (EEA) working papers (Breil et al., 2021; Lager et al., 2023), where justice principles are applied to the concept of resilience, but without a commentary on when, where and how these concepts may be compatible. Therefore, there is a growing use of hybridised concepts, such as 'transformative adaptation', 'just resilience' and 'just adaptation', that brings together the fields of resilience, environmental justice, and adaptation, and it is evident the three concepts are important in studying environmental change. However, there is little research examining the compatibility of these concepts, or potential assumptions that such concepts can be hybridised without contradictions. Therefore, further research that examines the relationship between these three concepts would be beneficial.

3.4.2 Evaluating adaptation: adaptation 'effectiveness'

As similarly found in this review with the concepts of resilience and environmental justice, there is ambiguity as to how adaptation can be measured. The IPCC's sixth assessment report (2022, p.49) uses a broad definition of adaptation effectiveness as "*the extent to which an action reduces vulnerability and climate-related risk, increases resilience, and avoids maladaptation*". Meanwhile, the legally binding Paris Agreement (United Nations, 2015, p.1) calls on nation states to undertake "*an effective and progressive response to the urgent threat of climate change*", alongside a global goal for adaptation. However, there is no widely accepted and applied understanding of adaptation effectiveness because of the variety of scales, local context, and range of academic disciplines with which it is studied (Dilling et al., 2019; Owen, 2020; Singh et al., 2021). Furthermore, there are numerous potential goals of adaptation (Singh et al., 2021), and the decision of who or what to adapt, and where and why, is highly subjective according to individual judgement and context-specific factors, raising environmental justice implications on how adaptation strategies are designed and implemented (Dilling et al., 2019; Owen, 2020; Singh et al., 2021). Owen (2020)'s systematic review on adaptation practices globally points to six aspects of adaptation effectiveness: increased resilience, wellbeing, adaptive capacity and social/natural system functioning; or reduced vulnerability or climate impact (several of these aspects are present in the IPCC's (ibid) definition). There is ample work that broadly examines adaptation effectiveness (Doswald et al., 2014; Singh et al., 2021), but this has not been applied to the context of sandscaping.

As highlighted in Chapter 2 (section 2.3.2), existing research on beach nourishment and larger-scale mega-nourishment such as sandscaping has focused on the geomorphological response of the coastal system. It therefore considers effectiveness in terms of how such schemes reduce physical coastal flooding or erosion risk (Stive et al., 2013; de Schipper et al., 2016; Hoonhout and de Vries, 2017; Luijendijk et al., 2017; Martell et al., 2020; Bolle et al., 2020; Roest et al., 2021). This view of effectiveness does not consider social factors, as proposed by the IPCC (ibid). De Schipper et al. (2021) propose that beach nourishment evaluations need to go beyond geomorphology, to a more holistic consideration of social, economic and environmental impacts. The authors (ibid) highlight the social impacts of beach nourishment on recreational use of the coast, tourism, and property prices. Therefore, evaluating the coastal management strategy in this thesis' case study requires a holistic definition of effectiveness, that draws upon the experiences and perspectives of relevant stakeholders. To explore adaptation effectiveness, it is necessary to consider how adaptation and coastal change are perceived by the communities affected, which is reviewed next.

3.4.3 Public perceptions of adaptation

Section 3.2.4 has already explored the factors that enable or constrain adaptive capacity to environmental change. This section compliments section 3.2.4, by focusing on intrinsic, cognitive-related factors that shape how people perceive an environmental policy or scheme. Folke et al., (2010) describe social perceptions as 'deep' and 'slow' variables that are significant in determining the eventual adaptation that takes place in socio-ecological systems. From a review of literature, factors affecting public perceptions of adaptation are summarised in Figure 3.5 according to three observable overarching themes; distributional, place-based, and values-based concepts and beliefs. Each is reviewed next in turn.

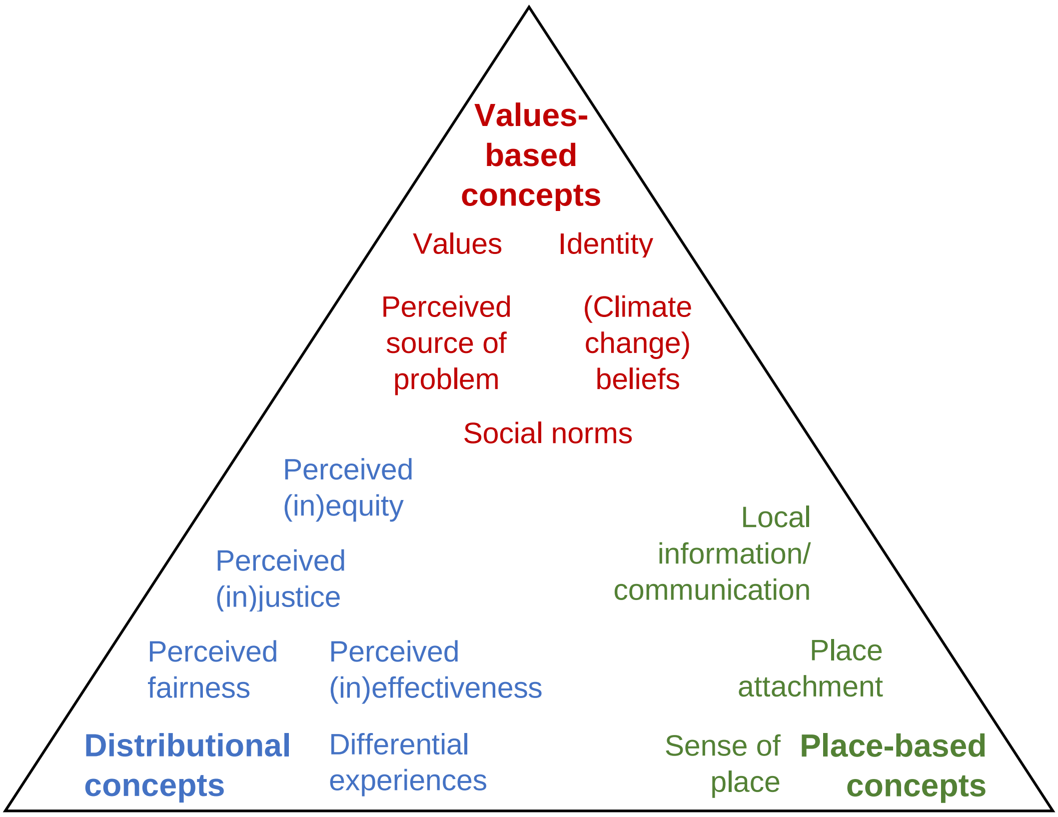


Figure 3.5 Factors affecting public perceptions of adaptation responses, grouped into distributional (blue), place-based (green) and beliefs or values-based (red) concepts. Categorisations are not exhaustive, and are based on a review of academic literature to identify observable overarching themes (Figure: I Cotton).

Distributional concepts

Turning first to distributional concepts (in blue in Figure 3.5), it has long been argued that public acceptability of a policy is influenced by perceptions of fairness, and determines legitimacy (Tyler, 2000). Adger et al., (2016) found legitimacy in adaptation governance, in terms of the extent to which authorities acted sufficiently and extensively, and equity in how flood impacts were spatially distributed, were two key factors affecting community willingness to adapt in two flood prone areas in Cumbria (England) and Galway (Ireland). Lau et al., (2021) similarly found perceptions of fairness, in terms of unequal access to fishing, impact an individuals' attitude, and actions, to coastal resources management in Papau New Guinea. Therefore, adaptation policies that are unjust in terms of equity of impact can be perceived unfavourably. Perceived inequity is found to vary within a community: acceptability of air quality measures proposed in London were found by Dietz and Atkinson (2007) as determined in declining importance by how it personally affects the individual, their closest friends or relatives, and subsequently according to worldview and values (the latter, values and beliefs, is discussed in further detail below). Furthermore, the authors (ibid) argue that within communities, individuals with the most similar characteristics and experiences of the expected benefits and harms from an adaptation policy will coalesce as a "*community of justice*" around a set position (Dietz and Atkinson, 2007, p.446). Therefore, it is relevant to explore not only how individuals are differentially impacted, but how they perceive themselves and others are impacted by an adaptation policy, and the perceived effectiveness of the policy itself.

Place-based concepts

Turning next to place-based concepts (shown in green in Figure 3.5) the influence of sense of place, which describes an individual or communities' impression, connections and emotions of where they live, has been well studied (Wolf et al., 2013; Quinn et al., 2015). Previous research has indicated that communities can be hesitant about changes to their local area which disrupt their sense of place (Quinn et al., 2015). In Clontarf, Northern Ireland, Clarke et al., (2018) report on a local community that recognised the need for, but nevertheless were against, the proposed flood mound and wall because it altered the physical landscape and seascape. Day et al., (2015) similarly argue that policies to manage coastal erosion, such as the demolition of pre-existing hard defences, equally interrupted sense of place for local communities in Norfolk. Sense of place is not necessarily homogenous for all individuals within a community, particularly when temporal questions arise on how to adapt to future climate change (Few et al., 2007). During the implementation of the 2012 Defra Pathfinder programme at Happisburgh, local opinion on the proposed adaptation measures (the retreat of the car park and dereliction of seafront houses) was split between residents who wanted the local environment to stay the same and residents who felt that change, in order to protect the most vulnerable residents, was necessary (O'Riordan et al., 2014).

Sense of place has been explored in relation to, and appears to strongly correlate with, individual property. O'Donnell (2019) argues residents in coastal Australia exposed to flood risk were more concerned about damage to their property than their local environment. The author (ibid) also found a link between sense of place and climate risk, where residents sceptical of climate change justified their views through sense of place. Previous research in Happisburgh (Tebboth, 2014) revealed some local residents do not primarily attribute accelerated coastal change with climate change; dredging and the removal of coastal defences were instead seen as bigger contributors. This highlights that, alongside sense of place, beliefs about climate change, and the perceived source of the problem, is a key factor through which residents process perceptions of adapting to environmental change, and potential solutions. The following section continues to explore the role of beliefs and values-based concepts (shown in red in Figure 3.5) in influencing public perceptions.

Values-based concepts

There are numerous studies examining the role of an individual's values in shaping perceptions (and acceptability) of adaptation measures (Adger et al., 2009; NCCARF, 2010; Graham et al., 2014). A study by Prati et al., (2016) found the local community and key stakeholder groups of Portonovo Bay (Eastern Italian coast) had different viewpoints on beach nourishment because of differing individual values and ideas of what needs to be protected. Those who viewed erosion more negatively were more likely to support the intervention, and place less weight on any negative impacts associated with beach nourishment (Prati et al., ibid). The authors (ibid) argue differences in perceptions stem from differing values on protecting the environment; for some residents, protecting tourism and use of the coast was the most important concern (anthropocentrism), whereas for other residents, allowing coastal ecosystems to function naturally in response to coastal erosion was seen as critical (ecocentrism) (Prati et al., 2016). An individuals' values, and beliefs about climate change, can be influenced by social norms that in turn, influence perceived acceptability for adaptation measures (Tompkins et al., 2010). Bontje and Slinger's (2017) analysis of perceptions of the Dutch mega-nourishment scheme (the Zandmotor scheme) found differences in narrative of the scheme, as told by stakeholders, at the local and national level. Therefore, the voices of local actors and social networks in ones' own locality influence how an adaptation scheme is framed and perceived, and views may differ amongst different social groups.

3.4.4 Risk perceptions and anticipatory adaptation

The CCC's (2018) review of coastal adaptation, and 2021 progress report (CCC, 2021) calls for greater consideration of longer-term adaptation to coastal change. Preparing for future adaptation ('anticipatory adaptation') has been explored within the literature to mixed findings on its advantages and challenges: whilst it is strongly argued in academic literature, grey literature on coastal management, and coastal policy that communities need time to prepare for coastal adaptation (Day et al., 2015; Mott MacDonald, 2016; NNDC, 2016; EA, 2020), other authors have argued an overemphasis on time, and an overemphasis on the future, affects the way the public adapts to climate risks in the present (Nobert and Pelling, 2020). The negative impact of risk reduction on behaviour and perceptions has been studied in international contexts, for example younger residents in Japan who are less concerned than older residents about the risk of tsunamis, which may be due to a lack of direct experience (Arias et al., 2017). Studies by Wolf et al., (2009) and

Nobert and Pelling (2020) on perceptions of extreme heat events for elderly residents in the UK found the majority of interviewees took little preparatory action (for example, retrofitting the house with air conditioning). Instead, the majority of adaptation was reactive during a heatwave event. Although anticipatory adaptation was stressed by local authorities, Nobert and Pelling (ibid) found the focus on future impacts did not resonate with interviewees, who perceived risk in the present moment and felt they could adapt at the start of a heatwave. Lack of anticipatory adaptation to climate change has similarly been found in coastal contexts (Few et al., 2007).

Other studies have shown a variety of factors contribute to social risk perceptions and form a barrier to anticipatory adaptation. Previous research has shown individuals consider society at large at greater risk of climate change than themselves, and therefore underestimate individual vulnerability (Sjoberg, 2000), and some individuals have a negative perception of adaptation, that the problem is too great to mitigate (Kollmuss and Agyeman, 2002). A correlation has also been found between risk perception and age with regards to flooding (Grothmann and Reusswig, 2006; Whitmarsh, 2008; Zaalberg et al., 2009). The relationship between direct experience of an environmental harm and risk perception has also been studied, of which there is a mixed picture. Whilst Whitmarsh's (2008) study on household perceptions of climate change adaptation in Hampshire did not find direct experience of flooding correlated with any greater concern of climate change, or behavioural response (i.e. taking adaptation actions), UK-wide research by Capstick et al., (2015) did find a link between flood experience and concern of climate change. Alongside age, an individual's environmental values were found to be a greater predictor of climate change concerns and adaptation behaviour than experience of flooding in Whitmarsh's (ibid) study. It is therefore relevant to explore social risk perceptions of future coastal change to understand implications for anticipatory coastal adaptation.

3.5 Conceptual framework

3.5.1 Summary of key gaps across chapter and theoretical insights

This thesis draws upon the fields of resilience, environmental justice, and adaptation to develop a conceptual framework that explores the impacts of sandscaping and implications for coastal resilience. Drawing upon the research reviewed above, and a systems framing as highlighted in section 3.2.2, this research examines in what ways sandscaping can be considered a transformative adaptation strategy (i.e. at what scales and parts within a socio-ecological coastal system). Transformation is the highest resilience category as presented by the authors in Table 3.1. However, sections 3.2.3 and 3.2.5 highlight that this appears based on theoretical assumptions that the greatest amount of systems change leads to increased resilience, with ambiguity on the link between transformation, maladaptation and uncertainty, and how this relates to whether adaptation is deliberate (i.e. anticipatory), or forced. This conceptual framework seeks to critically unpack the relationship between transformation and maladaptation, in three case study villages currently facing two different scenarios: Bacton and Walcott are temporarily protected from coastal risk by the nature-based solution sandscaping, while Happisburgh is not, and currently under a managed realignment SMP policy. As section 3.2.3 indicates, sandscaping is presented in the academic literature as a transformative adaptation strategy to managing the risk of coastal change.

This thesis takes an environmental justice lens, to not solely consider how resilience might be built at the system level, but how this varies across components (social, environmental) and scales (spatial, temporal). This research therefore moves from a typical analysis of ‘winners’ and ‘losers’ in the environmental justice literature, acknowledging the many trade-offs across scales that has been highlighted by literature in this review (sections 3.2.2 and 3.3.4). This is a research gap for the UK, with recent work on scale-sensitive distributional impacts based in international contexts (as seen in 3.3.4). Rather than ‘winners’ and ‘losers’ in where coastlines are defended, it is likely communities may experience a mix of positive and negative impacts by coastal change policies, and trade-offs on different spatial and temporal scales. By drawing upon the lived experience of communities, this research also explores justice issues of participation and recognition in coastal management. Key questions for exploring resilience from an environmental justice perspective, that draw upon the themes of research questions 2a, 2b and 2c (perceptions and experiences of coastal change), include;

- Where within the system is there evidence of increased resilience?
- Similarly, what are the impacts of sandscaping, and how are they distributed across spatial and temporal scales?
- Is there any evidence of (or risk of future) maladaptation?

An analysis of perceptions of sandscaping (research question 2a, Chapter 5), managed realignment (research question 2b, Chapter 6) and long-term coastal change (research question 2c, Chapter 7) allows this thesis to investigate social resilience, by examining factors that enable or constrain adaptive capacity. Adaptive capacity is focussed on, given that definitions of social resilience examined by this review (e.g. Folke et al., 2005; Maclean et al., 2016; EA, 2020; Howarth et al., 2020) describe social resilience using this framing. Therefore, adaptive capacity can be seen as central to understanding changes in social resilience. Section 3.2.4 has shown there are numerous social and institutional factors that affect adaptive capacity and in turn, resilience. While section 3.2.4 revealed that current coastal policy documents focus on factors that enable or constrain capacity to prepare, this review has shown that capacity to recover and capacity to adapt factors are also relevant. In addition, section 3.4.3 has shown there are a number of cognitive-related factors that influence public perceptions of a policy, of coastal change, and willingness to adapt. All of this is drawn upon here, ultimately to evaluate local resident perceptions of sandscaping, of wider coastal change, and connections between the two. This is conducted alongside investigating changes to physical resilience bought about by sandscaping, by looking at beach profile changes and sediment budgets at Bacton and Walcott before and after the implementation of the scheme, alongside cliff retreat estimates for Happisburgh.

This fills several gaps that have been identified in this chapter: a research gap on the social impacts of sandscaping (Chapter 2, section 2.3.2, and Chapter 3, section 3.4.2), an absence in coastal management policy on the specifics of building social resilience (Chapter 2, section 2.2.2, and Chapter 3, section 3.2.4), and a current policy gap in facilitating community preparedness for long-term coastal change (Chapter 1, section 1.1, and Chapter 3, section 3.4.4). In examining the above, this thesis considers the compatibility of merging the concepts of resilience and environmental justice into adaptation. Section 3.4.1 has shown it is commonplace to hybridise these concepts, with less research examining their compatibility. Furthermore, section 3.2.6 of this review revealed the concept of resilience is hard to measure, variably measured, and such ambiguity both leads to and masks disproportionate impacts, with resilience focusing on change for an overall system, rather than at finer scales (Mikulewicz, 2019). Considering both an individual, village and system scale in this thesis, by critically analysing social and environmental resilience from a scale-sensitive, justice perspective, allows this thesis to evaluate differences in scale or focus for resilience, environmental justice, and adaptation.

3.5.2 Conceptual framework diagram

Figure 3.6 illustrates the key concepts and interrelationships of the conceptual framework. The first yellow box in bold represents the central aim of the thesis, which is to explore the impacts of sandscaping and implications for coastal resilience. Transformation, and its relationship with maladaptation, is represented in the yellow boxes underneath, as a relationship that will be tested in this research. Given that positive and negative impacts of interventions can manifest at different parts of a socio-ecological system (i.e. social and environmental components) and on different scales (temporal and spatial), these four different facets are shown next, in the green boxes. The green boxes represent the scale-sensitive, environmental justice lens of this thesis. The row of red boxes considers how local residents both experience and perceive sandscaping, and in terms of changes to adaptive capacity. The influence of different adaptive capacities, and aspects of coastal management, are recognised in the white boxes at the end of the diagram.

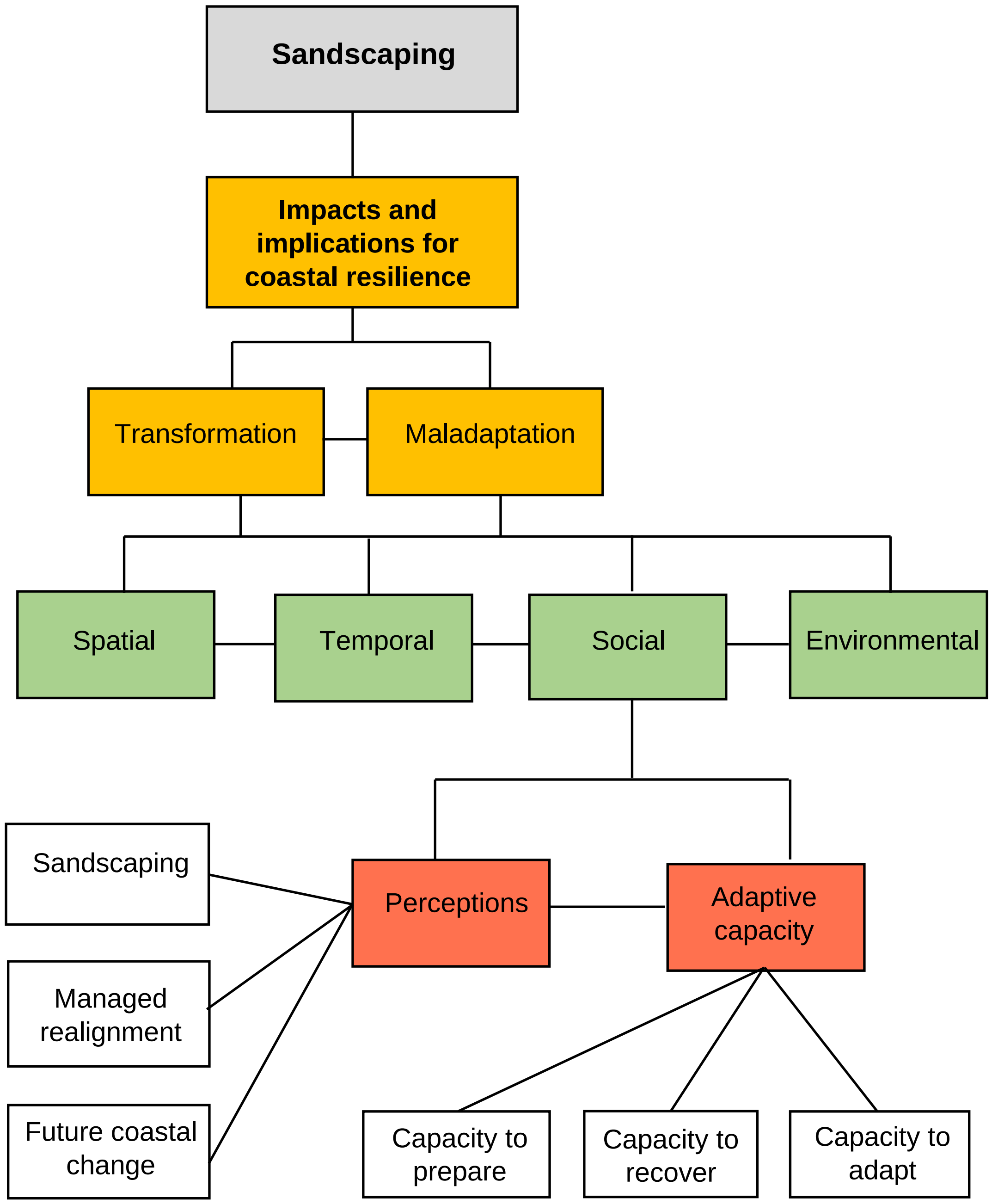


Figure 3.6 Conceptual framework diagram. Boxes in yellow refer to resilience, boxes in green refer to scalar elements of environmental justice, and boxes in red refer to perceptions of adapting to coastal change. Boxes in white refer to factors that influence adaptive capacity (bottom of diagram) or different subjects of coastal change (left of diagram) (Figure: I Cotton).

3.6 Concluding remarks

In conclusion, this literature review has explored the fields of resilience, environmental justice, and adaptation to develop a conceptual framework that examines the impacts of sandscaping and implications for coastal resilience. This literature review has highlighted key questions in the application of resilience to coastal management policy; namely that a systems framing could overlook impacts within the human sphere of a coastal system. Meanwhile, the reasoning that transformational approaches lead to the greatest system resilience, and reduce the risk of maladaptation, has been empirically underexplored. An environmental justice lens and scalar focus allows this thesis to consider how the impacts of sandscaping, and resilience, vary spatially, temporally, and for local communities and the environment. This provides evidence on how issues of justice can be better incorporated into adaptation strategies, such as novel nature-based solutions, aimed at building resilience. The following chapter outlines the methodological approach of the research.

4. Methodology

4.1 Introduction

This chapter outlines the overall methodology and research design of the thesis. While an overview of data collection and data analysis is given in this chapter (4.3 and 4.4, respectively), further details about the analytical approach are provided in the relevant results chapters (Chapters 5-7). This structure is used because the results chapters all draw upon different data, and therefore have a different focus in data analysis. The intention is therefore that this chapter provides a top-level overview of methodology, and that this is complemented by the relevant detail provided in each of the methods sections of Chapters 5-7. This chapter opens with an overview of the epistemological position of the thesis (section 4.2), and the choice to use a case study and a mixed methods approach. The research instruments used in this thesis (geomorphological analysis, survey, interviews) are introduced next (4.3), providing justification for why each was selected. Section 4.4 details the overall analytical approach, ending with an overview of the main ethical issues and limitations of the research (4.5).

4.2 Overview of research design

There are three key aspects of this thesis' methodology; 1) an epistemology grounded in critical realism, 2) the use of mixed methods to create an integrated, iterative research design, and 3) a case study approach. The following section outlines why each of these aspects were selected, and their importance to the overall research design.

4.2.1 Epistemological and ontological position

There are numerous ontological phenomena considered in this thesis, which include (but are not limited to) people's perceptions, beliefs, observations, and their interpretations of these; perceptions of community, of others, of self, and of collective responsibility (Mason, 2002). The above are aspects of the social world (Mason, 2002), but this thesis also considers environmental phenomena, such as cliff and beach elevation, beach volume, and natural coastal processes that cause sediment redistribution and coastal change. It therefore considers multiple forms of knowledge informed by the social and natural sciences. To reflect this, the research draws upon a philosophical position of critical realism, and theories of social constructivism, that there is both an objective reality and our socially produced, subjective interpretation of it (Bhaskar, 1975), depending on the phenomena studied (Sumner and Tribe, 2008). Critical realism accepts the world, and 'knowledge', is seen through a human lens (Bryman, 2006), and social constructivism posits that aspects of society are socially produced. This research adopts a paradigm that is a combination of critical realism and social constructivism. It argues, like Wiltshire (2018) and Bogna et al., (2020), that a hybrid philosophical position offers unique broader findings and a richer interrogation of the subject matter than one position alone.

It is necessary for this thesis to have an epistemology that sits between positivism and interpretivism, because the social and natural sciences suit different epistemologies (Bryman, 2006): in the social and natural world, different aspects of reality are being considered. Each is governed by their own set of processes, and choosing a purely positivist or interpretivist standpoint would be inapplicable to one or the other. In other words, believing there is no objective reality (constructivism) would be problematic for studying physical laws of nature, in the same way that believing there is no socially produced reality (positivism) would be problematic for studying social systems (Maxwell and Mittapalli, 2010). Furthermore, how the study is presented to participants, and interactions with the researcher, will influence participant responses. The positionality of the researcher, and how they are perceived by participants, has a bearing on the qualitative results collected in this research.

Maxwell and Mittapalli (2010) highlight the advantage to a constructive middle ground epistemological position, arguing an openness to other epistemologies itself opens up not only a greater opportunity for research findings, but epistemologically-critical findings. Research methods tend to reflect epistemological positions (Bryman, 2006), however this is not a clear-cut distinction, as both quantitative and qualitative research methods can explore social perceptions and actions, and use numeric metrics (Bryman, 2006). It has been argued that critical realism is an epistemology that lends itself to a mixed methods approach, given it can be applied to both quantitative and qualitative stances, but can also highlight where each method has its shortcomings (Maxwell and Mittapalli, 2010). This thesis' epistemology of critical realism therefore lends itself to a suite of particular research methods, which will be outlined in the subsequent section. With regards to this study, LiDAR (Light Detection And Ranging) data is used to analyse coastal processes (quantitative analysis), and surveys and interviews are used to analyse public and policymaker perceptions (largely qualitative analysis). Analysis of coastal processes is considered to be limited by data accuracy, coverage, and the degree to which sampling at a particular point in the year is representative (e.g. of seasonal coastal change). For the latter, there is a 'true reality' of the rate of coastal erosion, limited by data collection and analysis choices, whereas for the former, how people feel about sandscaping will be more changeable, socially produced, and therefore difficult to observe as a ‘true reality’.

4.2.2 Mixed methods

A mixed methods approach is adopted to answer the research questions (see section 1.4) on local resident and policymaker perceptions and experiences of coastal change, alongside geomorphological changes. As highlighted above, mixed methods can be deployed where research questions cut across disciplines (and therefore ontological and epistemological positions) (Bryman, 2006) and require multiple research instruments to be answered fully. Given that the interdisciplinary nature of the research requires drawing upon both social and geomorphological data, both quantitative and qualitative research instruments are used to study a coastal system. An often-cited critique of mixed methods research is that it deploys research methods from conflicting epistemological and ontological positions (Bryman, 2006). Drawing upon the arguments by Bryman (2006) and Maxwell and Mittapalli (2010), this thesis combines epistemological and ontological positions, considering they bring unique insights when used together and integrated, as similarly argued above. This thesis uses qualitative and quantitative data, to complement insights gained from each and answer different aspects of the issue of coastal change in the study area (Clark et al., 2023). In doing so, this thesis addresses another common critique of mixed methods, that qualitative and quantitative components of a research project are typically kept separate (Cresswell, 2011). The remainder of this sub-section on mixed methods outlines *how* the thesis integrates and triangulates mixed methods within the research design.

A key aspect to the research is not solely the use of mixed methods, but the *close integration* of qualitative and quantitative methods, to create a *highly iterative* research design. Figure 4.1 illustrates this process. Coastal geomorphology data is used to inform the study of social perceptions, that in turn situates and highlights the significance of the geomorphological findings. This creates an iterative, circular process between the data, where each informs the direction, or focus, of the other. Comparing findings from the two datasets also provides unique insights not possible by focusing on one alone. Geomorphology and social perceptions are interdependent in the coastal system, so it is therefore pertinent to deploy and integrate mixed methods for the phenomena studied. Furthermore, mixed methods approaches are often used in case study research projects (Bell and Walters, 2014) which is also a key aspect to this research.

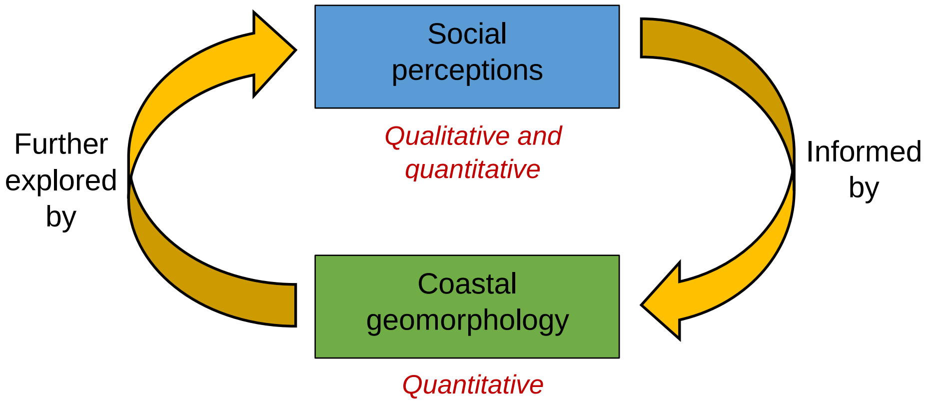


Figure 4.1 The close relationship between geomorphological and social data in this thesis (Figure: I Cotton).

Both Morgan (1998) and Cresswell and Plano Clark (2011) argue mixed methods research can be categorised into various approaches, depending on the degree and order to which research methods are applied. Figure 4.1 illustrates a similar method to Cresswell and Plano Clark's (ibid) Exploratory Sequential Design, where quantitative research methods are applied to inform qualitative research methods. Crucially however, this thesis adopts an iterative process, where each research method informs the direction of future geomorphological and social science analysis. Whereas Figure 4.1 emphasises this iterative nature, this is not as explicitly articulated in either Morgan's (ibid) or Cresswell and Plano Clark's (ibid) mixed methods archetypes. As well as adopting an iterative approach, this thesis also uses triangulation, comparing findings on a particular topic area using a survey and interviews (outlined next). It therefore attempts to do what Morgan (1998, p.372) refers to as "*true triangulation*" where quantitative and qualitative approaches are given equal weight and evolve in the research study at the same time.

Triangulation

Drawing findings from multiple research methods, potentially for the purpose of identifying whether both lead to similarly supportive findings, is referred to as triangulation (Bryman, 2006). In this study, both a survey and interviews were conducted to gather social perceptions of coastal change. By applying more than one method and triangulating the social data, unique limitations of a research method can be overcome with the strengths of another (Morgan, 1998), and findings can be consolidated (Bell and Waters, 2014). Another advantage of triangulation is it identifies findings that may be a product of specific biases with a research method (Morgan, 1998).

In this project, a survey was used to capture a range of opinions, and interviews were used to capture depth of opinion. This is a common method in human geography, to allow coverage of both the breadth and depth of an issue (Secor, 2010). Furthermore, understanding the range of public perceptions first (i.e. undertaking the survey before the interviews) allowed for a reflection on the most pertinent issues for local residents, and to design interview questions that investigated aspects arising from the survey. Deploying qualitative research methods (interviews) after quantitative methods (a survey) is a typical triangulation approach to further explore findings within social data (Bryman, 2006).

4.2.3 Case study

For this research, a case study approach is chosen, consisting of an in-depth analysis of coastal issues at Bacton and Walcott (protected by the sandscaping scheme), but also the adjacent village of Happisburgh, so as to elicit, explore and examine perceptions of locations at a (currently) defended and undefended coast (Mikkelsen, 2005). This is paired with an analysis of geomorphological change at the different locations within the case study area. The major advantage of a case study approach is its depth (Kitchin and Tate, 2000; Flyvbjerg, 2006; Cresswell, 2009), and is a key reason why it is adopted here. As revealed in section 2.3.2, there is minimal research to date on the social impacts of sandscaping. A case study is a suitable approach in this context, where sandscaping is a distinctive example of coastal management (Guest et al., 2013), and has been introduced to a specific stretch of coast (Swanborn, 2010; Guest et al., 2013).

One of the major criticisms of a case study approach is that it is contextual and cannot be considered representative of other situations or locations (Flyvbjerg, 2011); it cannot serve to draw transferrable findings (Flyvbjerg, 2006). Flyvbjerg (2011) argues that the focus on such aspects by critics reflects a wider preference within the social sciences towards theoretical rather than empirical insights, and the emphasis of gaining insights that may be transferable into other contexts. Such a position overlooks the value of case study research, of particular relevance here, which is findings are derived from the context within which they were studied. To date, there is only one sandscaping scheme in the UK, and very few schemes elsewhere in the world (as listed in section 1.4). Comparing the Bacton-Walcott sandscaping scheme to international schemes would be of little relevance to this thesis' research questions, because coastal policy can vary from country to country (for example, coastlines are defended indefinitely in the Netherlands, which is where the first mega-nourishment scheme is located). Hence the rationale for a one case study research design for this project.

As Flyvbjerg (2006: 2011) argues, a case study can be illuminating, if it has original aspects that mean it is insightful. In regards to the research in this thesis, there is an urgent policy need for research on how best to support communities in coastal areas at high vulnerability to coastal change, given the increasing coastal risk facing the UK (as outlined in Chapter 1), and a lack of guidance currently within coastal policy on this topic (as highlighted in section 3.5). Although case studies are geographically limited, this narrow breadth allows a detailed exploration of a subject area (Kitchin and Tate, 2000), which in turns makes it more likely that potential assumptions about a topic area (in this case public perceptions on coastal change) can be empirically tested (Flyvbjerg, 2006). The third research question of this study seeks to understand how the concepts of resilience and environmental justice might align (or not) in an empirical setting (in this case, coastal management policy). This requires the depth offered by a case study approach, which often generates process-orientated findings, in terms of how socio-ecological system components might relate to one another (Cresswell, 2009). Finally, as mentioned in the previous section, case study research often uses mixed methods (Kitchin and Tate, 2011), another key aspect of this thesis' research design.

4.3 Data collection

Geomorphological LiDAR data, a survey, and interviews were the three research instruments used in this research. The following section outlines why each was chosen, the sampling strategy, and the process for data collection.

4.3.1 Geomorphological LiDAR data

There are several methodological options to examine geomorphological coastal change, from manual methods such as walking surveys or photography (aerial and ground) to various different remote sensing methods, which can be ground-based, airborne, or use earth satellites. This study uses a type of airborne remote sensing, LiDAR, which measures elevation of the earth's surface by the time taken for radiation (in the form of visible light) to be re-emitted. Coupled with location data, this produces an output in the form of point cloud data (NOAA, 2023). LiDAR data was chosen, given it is a highly accurate data collection method to monitor changes in the profile of the coast (Gonçalves et al., 2019), and particularly applicable to fine substrate types such as sand, and gentle slopes (EA, 2019), which is the case on the North Norfolk coast where this research is situated. In contrast, alternative methods such as manual surveys and aerial photography can sample a wide area of the coast with accuracy, but are time consuming (Zhou and Xie, 2009). Where historically geomorphological changes were traditionally captured using manual field measurements, LiDAR data is increasingly being adopted as the technology improves (Rumson et al., 2019).

The advantage of remote sensing is the ability to capture a greater range of Aerial Optical Depth (AOD) accurately, and previous research indicates that coastal geomorphological processes at Bacton and Walcott take place up to a depth of -12 AOD (i.e. below tide) (RH, 2020). Furthermore, LiDAR data has specifically been applied to look at the effect of beach nourishment on coastal systems (Zhou and Xie, 2009), and is used by RH (who designed the sandscaping scheme) in their post-sandscaping monitoring work (RH, 2020). There is also an open access LiDAR data set collected annually at a national level by the EA, through the Anglian Coastal Monitoring (ACM) programme. Therefore, data to model geomorphological changes from the Bacton-Walcott sandscaping scheme were already available in the form of LiDAR data, which justifies the use of this particular remote sensing method.

Sampling strategy

To answer research question 1a, secondary LiDAR data is used to identify how beach profile and sediment volume have changed in the first 4 years of the Bacton-Walcott sandscaping scheme (2019-2022). Analysis of beach profile (Chapter 5) focuses on the villages of Bacton and Walcott, to compare observations with resident's experiences of the scheme, but analysis of sediment patterns (Chapter 7) covers the entire case study area (Bacton Gas Terminal to Happisburgh), to explore where placed sediment is migrating along the coast. Although attribution of geomorphological change to the sandscaping scheme is not possible, a before-after-control-impact analysis of sediment changes in this research can nevertheless reveal how the coastal system is responding. A sampling timeframe of 2015-2022 is chosen to account for year-to-year sediment differences, which can vary considerably due to variation in wave, climate and meteorological conditions (Leeder, 2011). Research question 1b analyses cliff retreat at Happisburgh from 2015-2022, similarly to compare observations with resident's experiences of coastal change. For the last part of research question 1 (1c), sediment volume for the case study area during pre-sandscaping years (2015-2018) is compared with the post-sandscaping years (2019-2022), to investigate if there is a statistically significant difference in beach volume that suggests the coastal system has been physically transformed by sandscaping, and to identify where this significant change has occurred.

This research uses two secondary datasets: annual LiDAR surveys produced by the ACM programme, and ad-hoc LiDAR surveys produced by RH. The ACM programme collects regular field surveys of various coastline environmental data including topographic and bathymetric LiDAR, and photography (ACM, 2022). Annual LiDAR datasets began in 2011, with field topographic surveys preceding them since 1987 (ACM, 2022). This is freely available to download (https://coastalmonitoring.org/cco/) as yearly digital elevation models. Data cells were imported into ArcGIS Pro, and combined into a uniform mosaic of the coastline at Bacton and Walcott. The ACM programme LiDAR data have 1 band, 1x1m resolution (cell size) and are 32 bit (pixel depth) floating point data type, extending to a depth of approximately –2m AOD. The data are watermasked (to avoid false elevation readings from the waters' surface). Voids, being generally less than 2m size, were left without interpolation in the digital elevation model, to avoid introducing inaccuracy. The second dataset used in this research is LiDAR and bathymetry surveys (combined into a single digital elevation model) collected biannually from 2019 by SHORE Monitoring & Research, on behalf of RH. Table 4.1 summarises key characteristics of each dataset, indicating why both are required in this research. Crucially, although RH data covers a greater vertical range, it does not extend to Happisburgh, one of this research's case study villages, and data before sandscaping is not available. This thesis requires four years of LiDAR data pre- and post- sandscaping to conduct a before-after-control-impact analysis. Therefore, this research extends the geomorphological analysis currently being undertaken by RH to identify changes in cliff retreat (Chapter 6) and sediment volume (Chapter 7) from Bacton to further south at Happisburgh.

Table 4.1 Secondary data sources for LiDAR data (Table: I Cotton)

	Anglian Coastal Monitoring Programme (ACM)	SHORE data by Royal HaskoningDHV (RH)
Time period	Since 2011 – ongoing	2019- ongoing
Access	Open-access, available through the Channel Coastal Observatory website[9], and the Defra Data Services Platform[10]	Not yet publicly available. Obtained for this thesis through a data sharing agreement
Vertical extent	Topographic and bathymetric (to -2m AOD)	Topographic and bathymetric (to -15m AOD)
Coverage	Entire North Norfolk coastline	Bacton Gas Terminal to 1.2km South of Ostend. Data does not extend past Happisburgh car park

4.3.2 Survey

A survey was chosen as the first social research instrument of this thesis, to give an initial, broad feeling of residents' views and experiences of the sandscaping scheme and of coastal change. Key advantages of surveys are the greater number of possible responses, compared to interviews or focus groups, in a shorter period of time (Cresswell, 2009; Secor, 2010). Furthermore, a survey can highlight the main issues for a population from a sub-sample (Cresswell, 2009). This reflects the purpose of the survey in this research, which does not attempt to derive representative findings of public perceptions at the population level . Rather, the aim of the survey was to elicit views on sandscaping, and the main issues of coastal change pertinent to local residents. Whilst the survey contained mostly open ended questions, some were also closed with a series of choice items.

[9] Channel Coastal Observatory https://www.channelcoast.org/cco/
[10] Defra Data Services Platform https://environment.data.gov.uk/

Another key advantage of a survey, relevant for this case study context, is that it was designed to be anonymous. An anonymous survey can give participants greater confidence in sharing negative perceptions on a topic matter, knowing their opinions are not personally identifiable (Lavrakas, 2008). Coastal erosion and coastal flooding are sensitive topics, with several residents having prior experience of coastal damage (as outlined in section 2.4.2, the 2013 floods inundated 200 properties at Bacton and Walcott). Coastal change could also be a divisive issue, in terms of differing public preferences for how coastal risk should be managed.

One of the major challenges of using a survey is it is highly sensitive to question wording, and unless questions are asked directly by a researcher, one cannot check if a respondent understood the question before results are collected. The implication is that different respondents may interpret questions differently, making it difficult to group and compare answers (Fowler, 2009). However, a trial run (piloting) of a survey can test for understanding, survey length, and allow an opportunity to adjust wording (Fowler, 2009). A pilot survey was arranged with 5 individuals (residents and local councillors from neighbouring villages), all of whom had pre-existing knowledge of the area or the sandscaping scheme, but did not live in Bacton, Walcott or Happisburgh. Care was taken to avoid subjective or vague wording in the design of the survey questions, and questions were tweaked after the pilot test, to improve clarity in wording. Survey questions were initially developed by reflecting on key topics from the conceptual framework, and research gaps identified in the literature review.

Sampling strategy

This thesis' case study has a definable sample population, where approximately 2,631 people live in the three villages (population figures shown in Figure 4.2 (ONS, 2011)). The population size of the case study area and a confidence interval were used to select the sample size of the survey. It is typical to adopt a 95% confidence interval in survey research (Lavrakas, 2008), which is a measure of the degree to which a survey sample is representative of the wider population. Therefore, given a population size of approximately 2,631 people and a 95% confidence interval, a sample size of 400-500 surveys would represent an approximate margin of error of 5%, also a typical standard in survey research (Lavrakas, 2008).

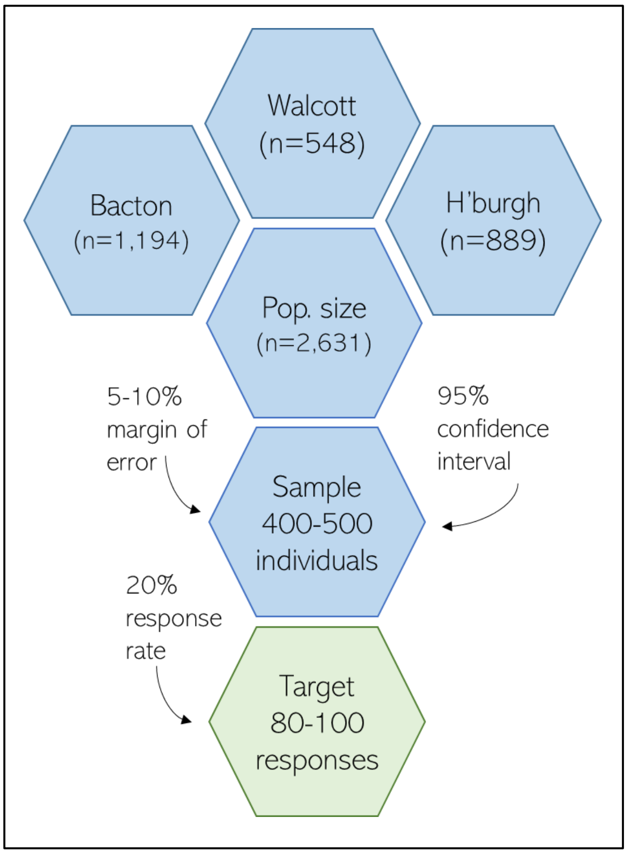


Figure 4.2 Sampling strategy and target responses for survey (Figure: I Cotton)

As the number of households is lower than the population estimates (single-person households in Bacton, Walcott and Happisburgh vary from 30-56% (ONS, 2021)) not all households were contacted. This thesis estimated 50% of households in each village would reach 400-500 completed surveys. This was also judged sufficient to capture the range of resident's opinion, where it has been shown new insights become increasingly limited after a certain threshold, alongside trade-offs with time and resources (Guest et al., 2013). Given previous survey research on public perceptions of beach nourishment yielded a response rate of 22% (Ariza et al., 2014), this survey anticipated a 20% response rate (80-100 completed surveys).

Households were selected through systematic sampling in each village. Flyers advertising the survey were put up in a few locations around the villages (the village hall and village shop), so that residents may already be aware of the research when surveys were delivered. High resolution Ordinance Survey maps from Edina Digimap (https://digimap.edina.ac.uk/) were downloaded and printed, and used to identify every other house where a survey would be delivered. There were a few exceptions which 'reset' the systematic sampling pattern. As this study sought perceptions from local residents only, holiday homes and holiday parks were excluded from the analysis, and houses where it was clear someone did not live there. It was decided that residents would have a stake on coastal change issues through primary residency (either property ownership or rental) that visitors would not. Where such holiday properties were identified, they were omitted from the survey, and the house next door was targeted. Systematic sampling of every other house was chosen to obtain a geographically-distributed range of potential responses within the villages, including residents immediately on the seawall or cliff edge, and those further inland. Previous research (Day, 2020) had adopted a similar sampling strategy in Bacton and Walcott, surveying for residents' views in 2019 prior to the sandscaping scheme, which proved effective.

The survey ran in a paper format, with the option to complete online, through a weblink provided in the information sheet, if preferred by the participant. The online survey was hosted through SurveyMonkey. The researcher delivered all surveys across Bacton, Walcott and Happisburgh over two days (Thursday 27th and Friday

28th January 2022). The researcher had a large print version of the survey on hand, should it be requested by any resident. Surveys were distributed directly through letterboxes, and participants were asked to leave completed surveys on their doorstop for collection the following week. Where residents were home, the researcher knocked on doors, aiming to introduce the research directly to as many households as possible, and provide an opportunity to ask questions. Care was taken to avoid double-counting respondents by limiting surveys to one household, and affixing a unique identifier number to each survey (if paper version), or to one IP address (if online version) (Gillespie et al., 2015)., following the method of Day (2020).

The survey was designed with neutral response answers, in case of disagreement with other answer options (Gillespie et al., 2015), and question design avoided ambiguity, leading, and double-meaning questions (Bell and Waters, 2014). The survey had 24 questions in total (see Appendix 1 for the survey and accompanying information sheet). The results chapters each draw upon different questions from the survey, topics of which are specified in sections 5.3, 6.3 and 7.3. Residents had a weekend to complete the survey, if they were returning the paper version. If residents were not around, the online survey remained open for a further month. Completed paper surveys were collected from residents' doorsteps (as per instructions in the information sheet) on Monday 31st January and Tuesday 1st February 2022. Given the researcher, on foot, could only be in one village at once, the researcher enlisted support of an assistant during collection, to lower the risk that paper surveys were missed if participants put out their survey later on in the day. A total of 485 surveys were delivered to residents, of which 100 were completed, 86 of which were paper surveys, and the remaining 14 surveys were completed online. This yielded a response rate of 21% overall (20% Bacton village, 22% Walcott village and 20% Happisburgh village), similar to previous surveys of beach nourishment (for example Ariza et al. (2014), who had a response rate of 22.4%). 96% of residents surveyed were primary residents of the area, with 4% second-home owners who live in the area for part of the year. Some surveys were completed and returned for every street in which they were distributed.

4.3.3 Interviews

In this study, interviews were used as an opportunity to explore further issues or aspects raised by the survey, or aspects not covered in the survey questions. Where survey answers indicate an individual's overall position on sandscaping and managing coastal change, interviews provide an opportunity to understand the reasons, and significance of, such perceptions, and provide a richness in understanding resident's lived experience of coastal change that would not be possible to capture to the same depth with an open-text survey question (Kitchin and Tate, 2011; Guest et al., 2013). For policymakers, coastal change is a multifaceted issue, involving many stakeholders and many different policies across government departments, and this complexity would not be grasped without an in-depth conversation on the topic. In-depth qualitative methods are appropriate for exploring views and perceptions (Cresswell, 2009; Lindlof and Taylor, 2011; Kitchin and Tate, 2011; Guest et al., 2013). Interviews are suited to research questions investigating nuances in public views of an issue and are commonly applied when seeking to further understand participant perceptions and underlying motivations (Lindlof and Taylor, 2011). Although one disadvantage of interviews, in contrast to an anonymous survey, is it requires participants to 'present themselves' with their opinions, interview questions in this study were designed sensitive to question wording on coastal change issues. Moreover, questions were sent beforehand to participants, allowing time for participants to become familiar with the research.

Given this research is primarily concerned with what people think, and why, as opposed to how they live, participant observation, participatory-based, and other ethnographic methods were less appropriate for this study. While focus groups can be used to explore public perceptions, interviews are a particularly useful research method to explore sensitive topics (Guest et al., 2013). Some aspects of the topic of coastal change (e.g. policy support) is contentious, political, and will be perceived differently by different interviewees. It was felt policymakers and residents would not be as forthcoming in a focus group setting, or may serve 'diplomatic' views they perceive to be more socially agreeable (Kitchin and Tate, 2011; Guest et al., 2013). By contrast, an individual interview provides a space for participants to discuss the issue without potentially triggering different or upsetting views.

A semi-structured interview technique, for both local residents and policymakers, is used in this research, with a pre-designed list of questions. A semi-structured (rather than unstructured or fully structured) approach was deemed the most suitable in this research context, where there are relevant aspects to ask all interviewees as common questions, but space for unscripted questions, suitable for understanding individual experiences of coastal change (Guest et al., 2013). Semi-structured interviews therefore allow the advantages of both a structured and unstructured interviewing approach (Kitchin and Tate, 2011). Another key advantage is the method allows for some degree of participant framing of the issues discussed, in recognition that the positionality of the interviewer and the framing of questions will dictate what is being said to a certain degree (Lindlof and Taylor, 2011) (positionality is further discussed in section 4.5). It is challenging to predict all relevant questions prior to an interview, and spontaneous, follow-up questions can often reveal unexpected insights, as the participant leads the interviewer through their perspective on the issue (Guest et al., 2013)

Furthermore, time in the interview dedicated to free-flowing conversation can lead to the richest qualitative data (Lindlof and Taylor, 2011).

Interviews with local residents comprised of 10-12 initial questions, split into two parts. The questions and information sheet for Happisburgh residents were slightly different, with some questions about sandscaping omitted for lack of relevance, given the village is outside the area of the scheme. Interviews with policymakers had an initial 18 questions, split into three parts, but similarly some questions were omitted depending on if the policymaker had local, regional or national expertise. Overall, interviews varied in length from 20 minutes to 90 minutes. See the appendices for the interview schedules and information sheets for Bacton and Walcott residents (Appendix 2), Happisburgh residents (Appendix 3), and policymakers (Appendix 4).

The interview schedule was designed with neutral probing (Lavrakas, 2008) to minimise leading the participant. All questions were open-ended, and interviewees were sent a copy of the questions in advance (with the email noting the interview would not follow a rigid format, questions were a guide only). Given the sensitivity of the issue, sending a copy of questions in advance was important so resident interviewees could understand the research better and what topics the interview would cover, and therefore would feel more comfortable. For policymakers, pre-existing questions helped to focus the interview, given the vast possible questions on coastal policy. While no questions were removed after the first few interviews were conducted, question wording was edited sightly to improve clarity. As part of the iterative approach of the research design, policymaker interviews were conducted after resident interviews, to identify the main themes to which it would be beneficial to have contrasting resident and policymaker perspectives. Interviews with local residents were undertaken in Autumn 2022, and interviews with policymakers early the following year (2023) (see section 4.3.4 for more information on the timing of each research method in this study).

Sampling strategy

An option to leave contact details for further information about the interviews at the end of the survey yielded 37 contacts. Survey responses for these contacts were analysed, and participants were contacted in priority order to allow for a mix of residents from each village, with different views and experiences of sandscaping and coastal change alongside varying age, gender and length of residency in the villages. As illustrated in Figure 4.3, further participants were recruited through; snowball sampling with interviewees, community gatekeepers (introduced via interviewees), advertising on community pages, and from speaking to residents around the villages.

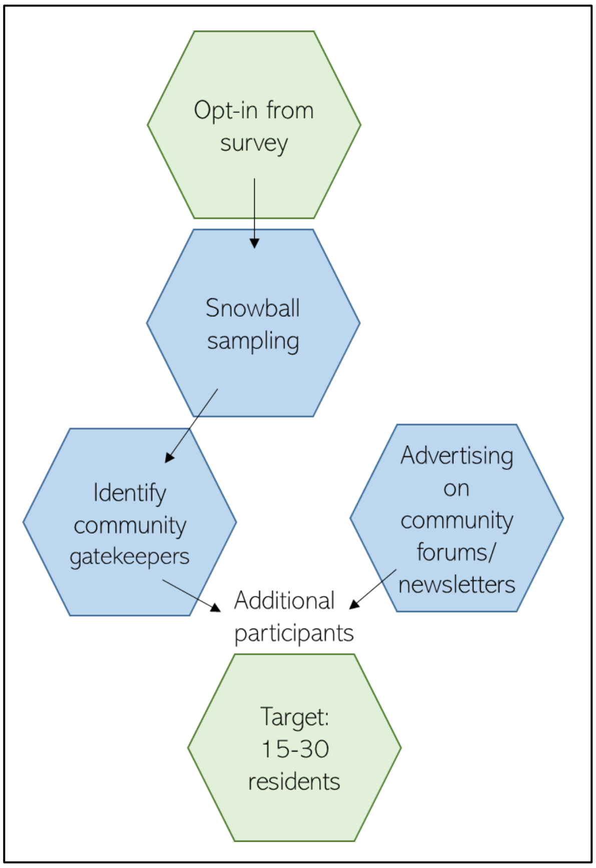


Figure 4.3 Sampling strategy and target responses for resident interviews (Figure: I Cotton).

In total, 30 residents were interviewed. At the participants' choice, 19 interviews took place in-person at a local village hall or café, eight interviews took place over the phone, and one online. The remaining two interviews were conducted outside on the seafront, as a walking interview, at the participant's preference. It was not possible to record (and therefore transcribe) these two interviews due to weather conditions, and so resident interview data (i.e. coding totals) reported in the empirical chapters do not include these two walking interviews. The resident interviews includes one instance where two residents (of the same family) preferred to be interviewed at the same time for logistical reasons, but each interviewee equally answered the interview questions and was coded separately. Interview data collection stopped at the point of thematic saturation and no further leads on participants.

In contrast, policymaker interviewees were identified through purposive sampling. Purposive sampling is suitable in this context, where there is a small and finite pool of relevant policymakers with a remit on sandscaping or coastal change issues in this case study context. Relevant policymakers were identified in collaboration with NNDC, the main gatekeeper of this project, who could provide introductions to the research via email. Given policymakers' role in the civil service or public sector, contact details were publicly available. In total, six policymakers were interviewed, comprising of two local, two regional and two at a national level, to get perspectives across policy jurisdictions and scales. At the participant's permission, policymaker interviews were conducted online, for logistical reasons (unlike residents, policymakers were based at different parts of the country, making in-person interviews challenging). Furthermore, at the time of the interviews (Winter 2022/2023), remote meetings were still commonplace following the Covid-19 pandemic. The 6 policymaker interviews includes one instance where two policymakers (of the same organisation) preferred to be interviewed at the same time, but each interviewee equally answered the interview questions and was coded separately.

4.3.4 Summary and timeline of research methods

Figure 4.4 shows the order and timing of data collection, as well as how each research method informed subsequent stages of data collection. Figure 4.4 demonstrates there is an iterative logic to the order of the geomorphological analysis and social research instruments (black arrows). But the diagonal arrows and italics free text illustrates some of the key themes that arose at each stage that also informed *across* the natural and social science analysis.

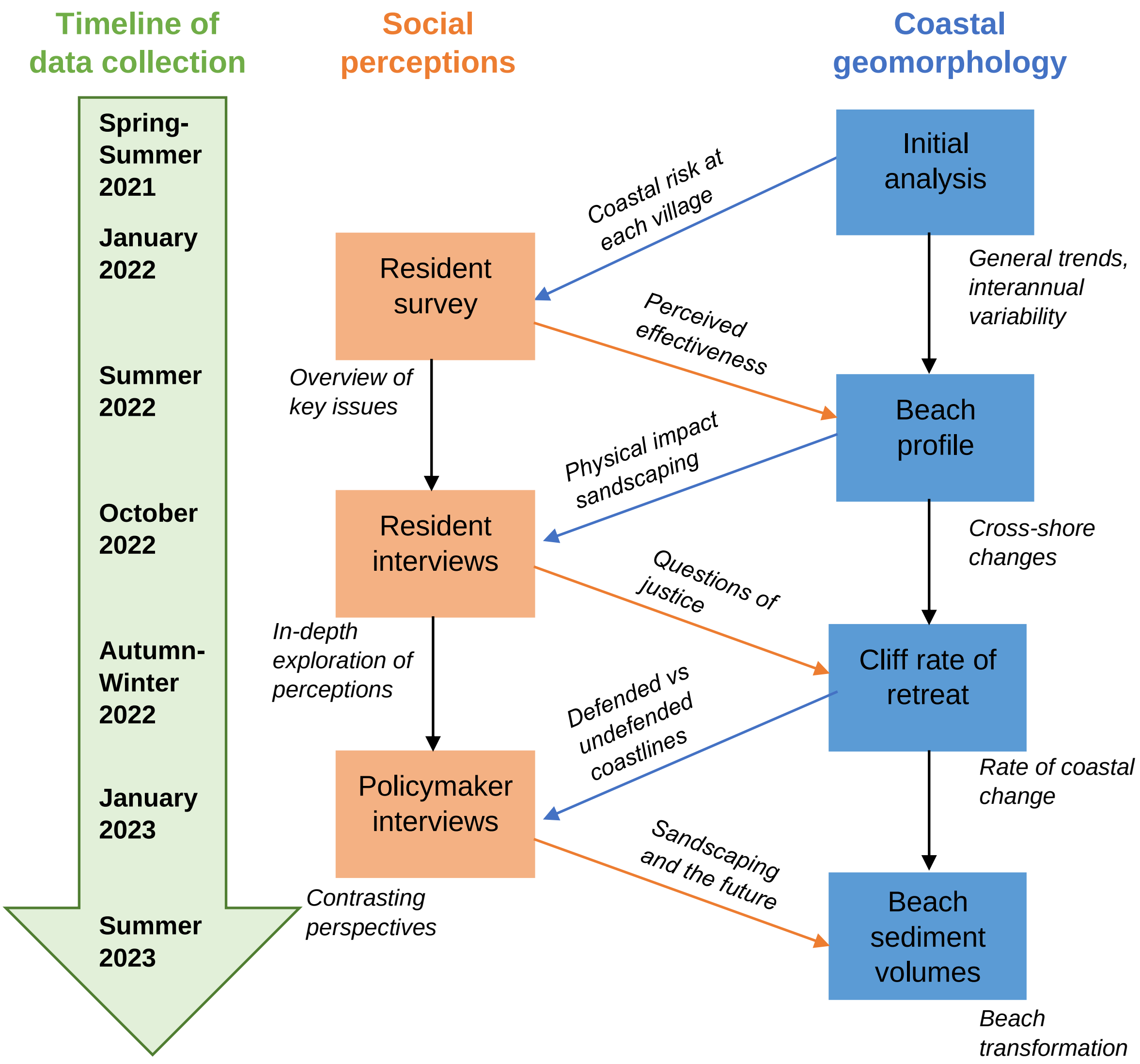


Figure 4.4 Timeline for research instruments used in this thesis (Figure: I Cotton).

4.4 Data analyses

This section describes the overall scope of the analysis, and justifies the analytical approach and the software used. More detail on the specific steps to geomorphological analysis (and for the survey and interview data, the topics analysed) can be found in the empirical chapters (sections 5.3, 6.3 and 7.3).

4.4.1 Geomorphological analysis

ArcGIS software was chosen to analyse LiDAR data, given it is a common software choice to analyse digital elevation models (Adhikari et al., 2016). This thesis predominantly used ArcGISPro (Esri, 2023), given it is a more sophisticated analysis software than ArcMap, with greater tools and functionality. While analysis was conducted in ArcGIS, Microsoft Excel was used to create graphs of geomorphological change, and to carry out statistical tests. This research identified three key geomorphological dynamics of the coast that local residents would observe and experience, but also would be impacted by sandscaping, and therefore could be investigated to explore whether sandscaping has physically transformed the coastal system. These were: cross-shore beach profile (Chapter 5), cliff rate of retreat (Chapter 6) and beach sediment volume (Chapter 7). See 5.3, 6.3 and 7.3 for an outline of how each geomorphological analysis was conducted in ArcGIS.

4.4.2 Closed-text survey questions

Survey questions and answers were manually inputted into a password protected Microsoft Excel sheet from the collected paper surveys and downloaded online surveys. Descriptive statistics were calculated in Excel for close-ended survey questions (i.e. questions that had predefined answer categories rather than a comment box), and used to create either a summary table or graph (pie chart or bar graph). See Appendix 5 for a breakdown of survey results by question. For open-text survey questions, responses were imported into NVivo. NVivo was chosen to store and analyse open-text survey questions, to allow this research to more easily compare codes and themes arising from the survey and interview data, as interview transcripts were also imported into NVivo. Both open-ended survey data and interview data were analysed using the same coding process and qualitative analysis (thematic analysis), which is detailed next.

4.4.3 Open-text survey data and interview data

Interviews were recorded using a dictaphone and transcribed verbatim using Microsoft Word’s transcription function (at the interviewees permission) and imported into NVivo. The transcription was manually checked and edited by the researcher for any inaccuracies to the audio recording. For policymaker interviews conducted over Microsoft Teams, an automatic transcript of the meeting was generated, and corrected manually for any errors. A separate folder was created in NVivo (release 1.6.1-1.7.1) (QSR, 2022) for interviews with Bacton, Walcott and Happisburgh residents, alongside policymakers, so that responses could be compared between villages and between residents and policymakers. The survey data was kept in a separate folder, with an anonymous survey ID number allowed for grouping answers by village.

Qualitative survey data and interview data were analysed using thematic analysis. Thematic analysis is a widely used analytical approach in the social sciences that identifies the main themes, or key ideas of significance, within a dataset (Braun and Clarke, 2006). Other approaches exist to analyse qualitative data, such as interpretative phenomenological analysis and narrative analysis, but these approaches are principally focussed on how data is communicated by participants, rather than the subject matter of what is being discussed (Braun and Clarke, 2006). Thematic analysis is therefore the more appropriate analytical approach for this thesis, given the research questions of this study aim to identify key issues in coastal management in the case study area (and therefore a focus on subject matter, rather than how it is told). Nevertheless, given this thesis takes a social constructivist position to epistemology, coding was mindful of both what is being described by participants, and how.

A three-step coding technique was used (i- initial, ii- focused, and iii- theoretical) advocated by Charmaz (2006), and developed from a grounded theory analysis approach by Glaser & Strauss (1967). Initially responses were read to simply identify what was being said. Next, this was used to develop groups of similar content, hereafter referred to as ‘codes’. In comparison to step 1, step 2 moved from simply describing data to grouping data according to shared meanings or significance. The researcher returned to survey responses or interview transcripts and coded text according to step 2 codes. This process involved iterations, through repeated reflection of the data and discussions with the supervisory team. The step 2 codes are the principal codes analysed in this thesis (and for the interview data, form the developed coding framework, see appendix 6), but are considered alongside step 3 codes. Step 3 codes were the final step of coding, and theoretically based, where the researcher returned to the thesis conceptual framework and literature review to identify codes that connect the data to the conceptual framework, alongside other pre-existing theories or frameworks. Following coding, similar step 2 codes were grouped (referred to as ‘parent codes’), and according to overarching themes.

These steps to coding were taken so that the researcher could evolve from more descriptive to interpretive coding, whilst staying ‘close’ to the qualitative data (Coffey and Atkinson, 1996). This allowed for both inductive (empirically driven) and deductive (pre-determined) codes, which allowed the research to consider unexpected themes that may not be included in the thesis framework or pre-existing research (an advantage of inductive coding), but also to connect and situate research findings to the research framework and existing research (an advantage of deductive coding) (Braun and Clarke, 2006). Figure 4.5 illustrates this approach to coding. Although qualitative survey data and interview transcripts were coded and analysed using the same approach, separate codes were developed for each dataset, given the research methods were conducted sequentially and focussed on different topics.

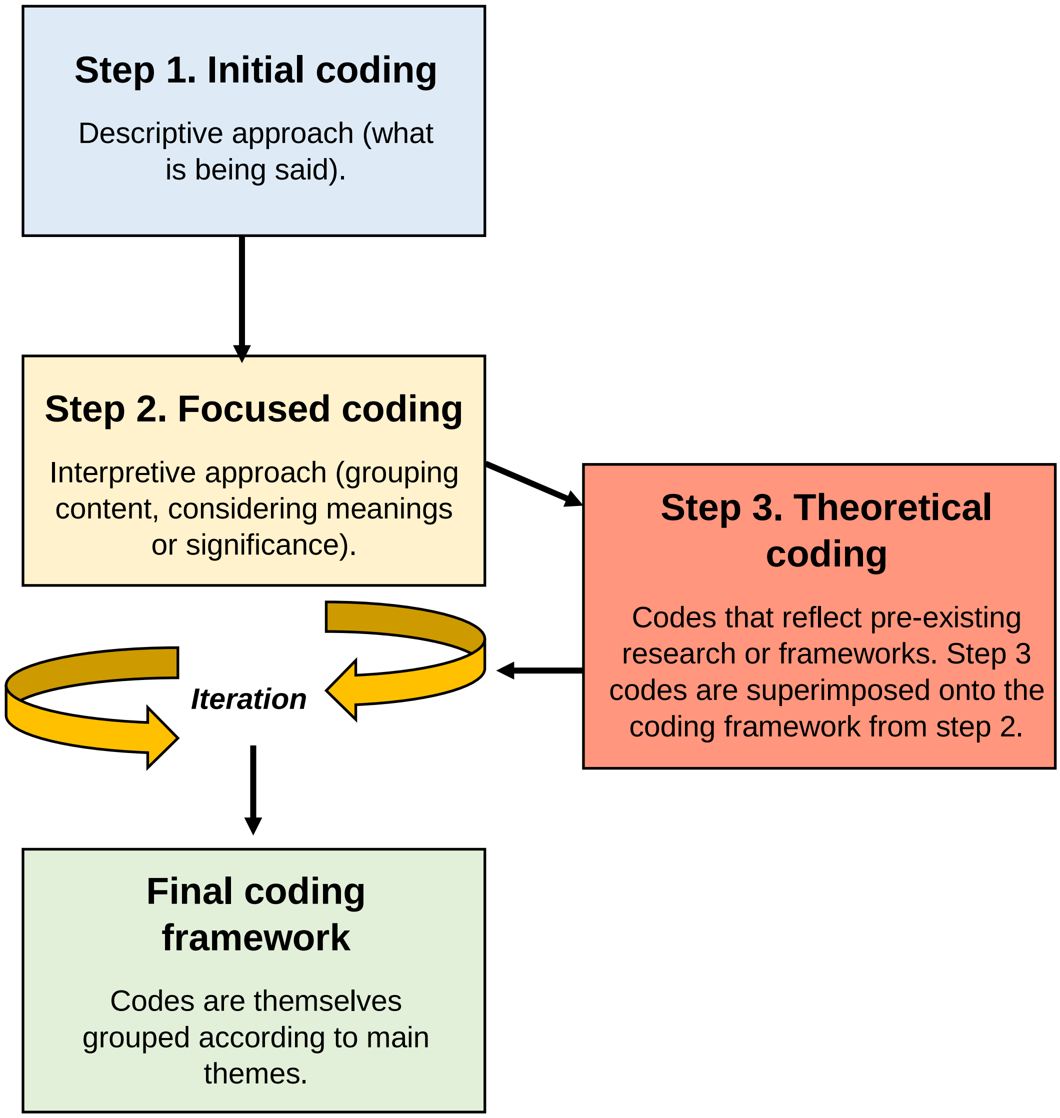


Figure 4.5 Steps involved in the coding process, leading to the development of a coding framework (Figure: I Cotton).

Overview of data presentation in this thesis

Figure 4.6 is an illustrated map of the data presented in this thesis. Each results chapter draws upon a different mix of data, across the different research methods. The methods section in each results chapter (5.3, 6.3 and 7.3) details the topics covered and analysis steps for social and geomorphological data in that chapter.

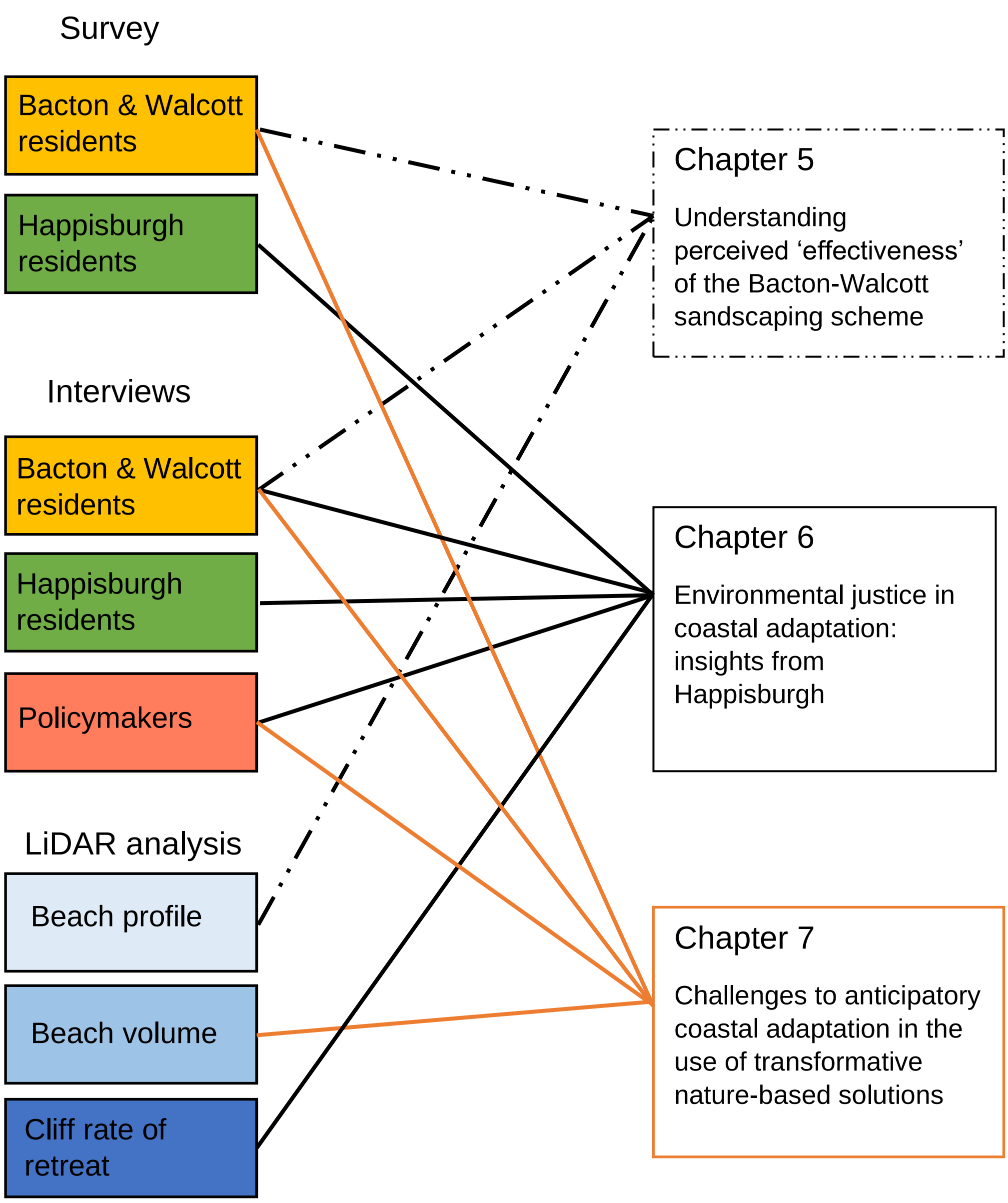


Figure 4.6 Map of data presented in each results chapter. The different research methods (survey, interviews, and LiDAR analysis) are sub-divided into data groups. For the social data, these groupings are Bacton & Walcott residents (yellow), Happisburgh residents (green) and policymakers (red). For the geomorphological data, these groupings are according to the topic of analysis: beach profile (light blue), beach volume (medium blue), and cliff rate of retreat (dark blue) (Figure: I Cotton).

4.5 Research ethics and limitations

4.5.1 Ethics

This research obtained ethical clearance (application number ETH2122-0192) from UEA DEV S-REC ethics committee in December 2021 prior to fieldwork, which as part of this process included completed risk assessments and contingency methodologies in case of disruption due to Covid-19 (See Appendix 7 for confirmation of the approved ethics submission). The following section details the main ethical issues pertinent to the research methodology.

Risk to participants

As described in chapter 2 (section 2.4.2) the villages of Bacton, Walcott and Happisburgh have previous experience of flooding, previous properties lost to erosion (BGS, 2021), and some residents reporting trauma from previous storms (Day, 2020). This research therefore explores a very sensitive personal topic, and the survey and interview schedule were designed sensitive to this, with no unnecessary questions asked. Although parts of the interview discussion were expected to be positive (i.e. the coastal protection benefits of the sandscaping scheme), previous research on Happisburgh highlights the emotive views of coastal erosion (Day et al., 2015). Therefore interview questions on future coastal erosion risk (the most sensitive topic) were asked towards the end of the interview, after more straightforward questions on perceptions of sandscaping. Research training was also completed, prior to fieldwork, on how to engage with communities on sensitive research topics. It was explicitly stated in the survey and interview information sheets that taking part is voluntary, and that participants could terminate the interview at any stage, should they wish to do so.

Informed consent

Participants require free, prior and informed consent in order to ethically engage with research (Sieber and Tolich, 2012). Separate information sheets for the survey and interviews were created, to explain the purpose of the research, topics covered, time asked of the participant, and to confirm anonymity and voluntary participation (Gillespie et al., 2015). Information sheets were checked against the ethical research guidelines outlined in DEV at UEA. Participants taking part in the interview were asked to sign, date and return consent forms to the researcher. Where written consent was not possible (in rare cases, where an interviewee couldn't sign for a practical reason), verbal consent to take part in the interview was given by the interviewee. Participants had an opportunity to ask further questions about the study at any time, with the researcher's email address provided. Participants were able to withdraw from the research at any point until submitting the survey or taking part in the interview.

Data use, storage and retention

Participants have the right to anonymity in analysis and write-up (Sieber and Tolich, 2012), with only anonymised excerpts used in the thesis. For interview participants, permission to record the conversation was explicitly asked at the beginning of every interview, and was explicitly stated on the information sheet. Interview transcripts were kept on the researcher's personal computer, and not shared with anyone else. Survey questions did not ask for participants name, address or contact details (a contact detail was optional at the end should participants want to participate in the interviews). The only personal data collected from the survey were a participant's age, in a closed-ended age bracket question format. Once collected, the survey responses were therefore not personally identifiable, as this was not necessary for the research. Contact details were stored securely on a password protected file in accordance with the General Data

Protection Regulations (GDPR), with the minimum amount of personal data necessary (ICO, 2018). It was stated in the survey and information sheet that contact details, should they be provided, were kept by the researcher alone, and not viewable or shared with anyone. Transcripts and survey data will be kept no later than necessary for the submission of the thesis and associated publications. The data policy for SurveyMonkey, which hosted the online survey, was checked beforehand in terms of complying to GDPR laws for personal data.

4.5.2 Limitations

The last sub-section of this chapter outlines the main limitations to the research design. Chapter 8 (section 8.5) returns to many of the limitations outlined here, discussing these in light of the research findings, and in relation to future work. The principal limitation to the study is that it analyses a coastal management scheme (sandscaping) in its first 4 years (2019-2022), rather than its full lifetime (expected to be 20 years). This simply reflects the timeframe of doctoral research (3.5 years) and the year in which sandscaping was implemented (2019). Therefore, this thesis can only provide early indications on the impact of sandscaping and changes to resilience. There is nonetheless still a rationale to researching sandscaping in the early years of the scheme, given it is being replicated in other parts of the world (as noted in Chapter 1, section 1.4). Furthermore, some social and geomorphological impacts as a result of sandscaping are likely to be instantaneous or apparent within the first four years of the scheme, and therefore an early study is still beneficial.

This doctoral project took place (2020 – 2024) during an unprecedented time for research, where there were significant policy restrictions due to the Covid-19 pandemic. This delayed the researcher travelling to the case study area, and the start of fieldwork. Fieldwork took place shortly after restrictions were lifted (January 2022). However, during the first year of the PhD, it was uncertain what policy restrictions there would be during fieldwork, therefore both an online and paper version of the survey and interviews were prepared, in case of tightening restrictions. This turned out to be advantageous, as the survey was administered in both formats and used by respondents, so it is likely the number of responses was greater than if solely a paper or online version had been used.

There are limiting factors to the research instruments used in this thesis, as also highlighted earlier in this chapter (section 4.3). Findings from the survey and interview data will be limited by the sample size and number of willing participants, and the timeframe available for fieldwork. Respondents who chose to take part may not disclose certain opinions, emotions, or experiences, given sensitivities of the topic area, or may express what they believe is the ‘correct’ view (Gulbrium and Holstein, 2000). It is therefore important to be mindful of potential biases, inaccuracies, or undisclosed perceptions associated with the social data. This was not notable during the fieldwork, but it is possible that survey and interview participants may have chosen not to disclose certain perceptions (for example, about the sandscaping scheme and coastal change). There is also a risk, particularly for the survey data, that participants may have misinterpreted the question. Triangulation of the survey and interview data allows the researcher to compensate for this, if it occurs, by gathering multiple data on a research topic and exploring themes using multiple research instruments.

Limitations with the geomorphology data generally relate to accuracy errors, with the associated errors in generating LiDAR data forming the largest total error in LiDAR analysis (Zhou and Xie, 2009). However, for the research questions in this thesis, understanding general trends on how beaches are changing, rather than absolute accuracy on beach profile, beach volume or cliff retreat values, is sufficient. Therefore, accounting for variation in how LiDAR data is generated by the ACM programme and by RH across years, and the influence of past meteorological conditions and storm surges on sedimentation patterns, while noteworthy from a geomorphological perspective, are less relevant in the context and scope of this research. Of relevance to comment on is the LiDAR data availability, which is one dataset per year for the ACM data, at varying times during the Winter season each year. This inhibits any analysis of seasonal changes, and furthermore the data is of a limited vertical extent to –2m AOD. The implication is that ACM LiDAR data may reveal sediment loss on the upper beach, when sediment gain may be undetected below the foreshore (beyond –2m AOD). Using the ACM LiDAR data in combination with the RH data overcomes this limitation, with the latter capturing elevation change to a depth of approximately –15m AOD.

Lastly, it is important to note the influence of the researcher's positionality in the overall research. Every researcher will have biases in how research is analysed and conducted depending on their academic background (Cresswell, 2009). As highlighted above in section 4.2.1, an interdisciplinary research study that draws upon a critical realism and social constructivism epistemological position allowed the researcher to consider findings across disciplines. Furthermore, a researcher's personal characteristics will have a bearing on how they, and the research, is perceived by participants (Folkes, 2022). A field diary was kept during fieldwork, to introduce a reflexive exercise to the data collection. By recording reflections with how the fieldwork went, the researcher was able to externalise reflections during data collection that may have a bearing on research findings (Folkes, 2022, Smith et al., 2021). The fieldwork diary was returned to and considered during the data analysis stage.

4.6 Concluding remarks

This chapter has provided a background to the methodology and research instruments used in this research. It has summarised the overall approach and research design of the work, in relation to data collection and analysis, as well as highlighting the main methodological constraints to the study. The following chapter (Chapter 5), is the first empirical chapter of the thesis, and presents findings in relation to research questions 1a and 2a.

5. Understanding perceived ‘effectiveness’ of the Bacton-Walcott sandscaping scheme

This chapter is based off the publication; Cotton, I., Forster, J., Lorenzoni, I. and Tolhurst, T.J. 2022. Understanding perceived effectiveness of a novel coastal management project: The case of the Bacton-Walcott sandscaping scheme, UK. Frontiers in Marine Science, ***9****, Article 1028819.* <u>*doi.org/10.3389/fmars.2022.1028819*</u>*. IC’s role in the paper: conceptualisation, methodology, data collection and analysis, writing (lead), review and editing*

5.1 Introduction

This is the first empirical chapter of the thesis, and presents results relating to the perceived effectiveness and impacts of sandscaping for Bacton and Walcott residents. As highlighted in Chapter 2, while nature-based solutions are increasingly being promoted over hard defences, there is a lack of empirical research on the effectiveness of novel approaches such as sandscaping, which are deployed at an innovative (larger) scale. This chapter explores research question 1a, in terms of analysing changes to beach profile, and research question 2a, by seeking to understand the range of social impacts residents may experience, and how ‘effectiveness’ of sandscaping is understood locally. This chapter therefore considers effectiveness from multiple perspectives (as advocated by the IPCC’s (2022) definition of adaptation effectiveness[11], section 3.4.2); both from a geomorphological perspective, in terms of the ability of sandscaping to reduce flood and erosion risk, and from a social perspective, drawing on the social experiences, impacts and perceptions of local residents over

[11] The IPCC (2022, p.49) defines adaptation effectiveness as “*the extent to which an action reduces vulnerability and climate-related risk, increases resilience, and avoids maladaptation*”.

time. Section 5.2 provides a brief overview of existing research on public perceptions of beach nourishment, and background to public communication of the sandscaping scheme in 2018 and 2019. Section 5.3 outlines the data presented in this chapter, and in particular the methodological approach to calculate beach profile changes. Sections 5.4 and 5.5 present and discuss the main findings, respectively, before a concluding summary of the chapter (section 5.6).

5.2 Background context

5.2.1 Public perceptions of beach nourishment

This subsection provides additional detail to the literature review (section 3.4.2-3.4.3) on public perceptions and perceived effectiveness of adaptation, by focusing here specifically on perceptions of beach nourishment and coastal nature-based solutions. As highlighted in section 2.3.2, there are few studies to date on local residents' perceptions of larger-scale mega-nourishment schemes such as sandscaping, with existing social research focusing on its unique governance and partnership approach (Vikolainen et al., 2017; Clipsham et al., 2018; Johnson et al., 2020b) or from the perspective of specific recreational users, such as wild swimmers (Radermacher, 2018).

Previous research on smaller-scale beach nourishment and nature-based solutions reveals a divergent range of views amongst stakeholders (Ariza et al., 2014; Prati et al., 2016), influenced by lived experience (Prati et al., 2016; Usher, 2021), and in some contexts, low levels of awareness of the scheme (Marin et al., 2009; Roca and Villares, 2012; McKinley et al., 2020). The range of views amongst stakeholders particularly relates to the perceived objectives of beach nourishment

(Ariza et al., 2014; Prati et al., 2016). Prati et al. (ibid) found that local stakeholders (that use, work near or study the nourished beaches of Portonovo Bay, Italy) who perceive erosion as a strongly negative process were more likely to support beach nourishment and were less concerned about any negative impacts. Further, Usher's (2021) survey of recreational surfers in Virginia, US, found varying perceptions in different areas, with more negative perceptions for beaches that have been more heavily nourished, suggesting beach nourishment has a greater impact on wave quality for surfers over time. Marin et al. (2009) explored local residents' perceptions of locally nourished beaches in northern Italy, finding low levels of awareness, with over half of respondents having not previously heard of beach nourishment. Of those aware of the scheme, 56% had negative perceptions of it, due to changes in sand grain size, and concerns over project cost, effectiveness (in achieving its objectives), and water quality. Other negative perceptions of beach nourishment by local residents include disliking wider beaches, despite the overall benefit of increased beach size (in Gold Coast, Australia) (Todd and Bowa, 2016).

Asides from beach nourishment, there have been several studies on public perceptions of other coastal nature-based solutions, which similarly show both a diversity of public views and low public awareness in certain contexts. McKinley et al's. (2020) national public survey of saltmarshes in Wales found uncertainty about their function and purpose: 15-40% of respondents selected 'unsure', when asked a series of questions on different benefits of saltmarshes. Roca and Villares (2012) also found low levels of knowledge on managed realignment amongst stakeholders who work or use the Ebra Delta in Spain, alongside a diversity of opinions, and low trust in policymakers. Indeed, other studies have found that trust in policymakers, in particular, is a key barrier in public acceptance of coastal nature conservation initiatives (Milligan et al., 2009) and of nature-based solutions generally (Anderson and Renaud, 2021). Methods of public communication was found by Schernewski et al. (2018) to be a key factor in whether coastal residents in Germany trust adaptation strategies.

Furthermore, existing research has found lower levels of perceived effectiveness of nature-based solutions when compared to hard defences. Roca and Villares (ibid) found that over 70% of stakeholders surveyed perceive a strategy of managed realignment as less effective (in reducing coastal erosion risk) than hard defences. Studies on nature-based solutions typically consider 'effectiveness' largely in terms of reduced coastal risk or increased coastal protection (Roca and Villares, ibid; Gray et al., 2017; Anderson and Renaud, 2021). Gray et al. (2017)'s interviews with coastal residents in the US state of New Jersey similarly revealed a perception that hard defences are more effective than natural infrastructure (i.e., nature-based solutions such as dunes), which suggests hard defences may be the preferred option to manage coastal change. Anderson and Renaud (2021) argue that nature-based solutions are 'judged' to a higher standard (for example in terms of effectiveness, value for money, and impacts) than hard defences, and argue that policymakers need to sell the benefits of nature-based solutions more persuasively. This is particularly crucial in a coastal context, where hard defences can increase the risk of erosion for adjacent coastal areas, and therefore are not always a viable option (French, 2004).

5.2.2 Public communication on the Bacton-Walcott sandscaping scheme

Section 2.4.3 outlines the Bacton-Walcott sandscaping scheme in detail, including the modelled expectations of the scheme, that placed sediment would migrate cross-shore and alongshore over time, but largely remain within the coastal system rather than migrating offshore (NNDC, 2022b). This subsection briefly provides additional context on what was communicated publicly in the years before sandscaping was implemented (2019) about how Bacton and Walcott beaches were expected to change. Several public engagement events took place before and during the implementation of sandscaping, which included a local liaison group of community members, village drop-in events, information letters to Bacton and Walcott residents, and temporary public information stands in the area (NNDC, 2017), alongside reporting in local and national news (for example BBC, 2017). The communicated objectives of the scheme include protecting the nationally important gas terminal and the adjacent villages of Bacton and Walcott from coastal erosion and flooding (RH, 2018a), and to "*provide time to the communities to adapt to coastal change*" (Johnson et al., 2020b, p.39). In this regard, sandscaping is framed as a nature-based coastal management strategy, that can also facilitate adaptation to future coastal change, given its predicted 20 year timeframe of coastal protection (Johnson et al., 2020b) (themes explored further in Chapter 7).

5.3 Materials and Methods

5.3.1 Data collection

Social data

This chapter draws exclusively upon the survey responses (77) and interviews (22) of Bacton and Walcott residents, and compares these perspectives with geomorphological observations of beach profile change at the Bacton and Walcott frontage. Bacton and Walcott residents are the villages closest to the sandscaping scheme, and unlike Happisburgh residents, are within the area of intended coastal protection from the scheme (and so are focussed on in this chapter). Chapter 4 details the sampling strategy for the survey (section 4.3.2) and interview (4.3.3) data collection, and a copy of the survey and interview questions can be found in the appendix (Appendices 1 and 2). Themes and topics reported on in this chapter, which form the basis of the structure of the results section (5.4), include:

- Do local residents perceive the Bacton-Walcott sandscaping scheme to be performing effectively (in the present day and the future) (section 5.4.1)?
- How do residents' perspectives compare with geomorphological observations (section 5.4.2)?
- How have residents been (positively or negatively) impacted by the sandscaping scheme (section 5.4.3)?
- What is the level of trust in coastal management decision-making for Bacton and Walcott (section 5.4.4)?

Subsequent to the survey data collection and analysis, semi-structured interviews were conducted in October and November 2022. The 22 interviewees included both participants that did and did not take part in the survey. Interview questions reported on in this chapter include further questions on the sandscaping scheme, such as how the beach profile has changed, perceived effectiveness of sandscaping as a coastal management strategy, official communication about the scheme, and communication preferences for the future.

Coastal data

To examine how the local coastline and geomorphology has changed at Bacton and Walcott since sandscaping was implemented, changes in the elevation and profile of sediment on the beach were analysed. Two sets of secondary data were used, covering areas of the coast to varying depths from the upper (dry) beach to the subtidal zone, over the period 2018-2022 (for ACM programme data) and 2020-2021 (for RH data, the more limited timeframe of which reflects data availability). Section 4.3.1 outlines the characteristics of both datasets, and justifies why both are needed to analyse changes to beach profile at Bacton and Walcott: crucially, the RH data samples elevation to a greater vertical extent (-15m elevation, sampled to up to -9m here) than the ACM programme data, revealing geomorphological changes below the foreshore. In addition, the ACM programme data, which has archives from 2011, is used to illustrate beach profile in the year before sandscaping was implemented (2018).

5.3.2 Data analysis

Social data

As detailed in Chapter 4 (4.4.2 and 4.4.3) survey responses were inputted into Microsoft Excel to produce descriptive statistics and summary charts for quantitative, closed-ended questions, while open-ended survey questions and interview transcripts were thematically analysed. Details on the 3-step coding technique to thematic analysis (i- initial, ii- focused, and iii- theoretical, advocated by Charmaz (2006), and developed from a grounded theory analysis approach by Glaser & Strauss (1967)) in particular are detailed in section 4.4.3. Triangulation of the survey responses and interview transcripts was used to gather data about perceived effectiveness from multiple research instruments. In particular, the interview data allowed greater depth of insight into perceived effectiveness and the ability to clarify any ambiguity in certain survey responses.

Coastal data

Digital elevation models of the secondary LiDAR data were viewed and analysed in the mapping software ArcGIS Pro. ArcGIS Pro was chosen over ArcMap, because it offers greater functionality to draw line transects in ArcGIS that was needed for the analysis. To calculate changes in beach profile before and after the implementation of sandscaping, aerial photography (available as an ArcGIS Pro basemap layer) was used to identify the location of the sea wall at Bacton and Walcott, which was used as the starting point for line transects, in a seawards direction. The most popular areas of Bacton and Walcott beach, as identified by aerial photography, were sampled (starting at Bacton car park in Bacton and opposite the amenities on Coast Road in Walcott). Perpendicular line transects to the sea wall were generated, spaced 100m apart. In total, 9 line transects were used to sample the beach in each village. After trialling different sampling frequencies, elevation was sampled at points every 1m along each line transect. Data was exported to Excel and an average for each set of 9 transects sampled at Bacton and Walcott was used to create a line graph of cross-shore beach elevation changes. This analysis was conducted for both the ACM programme and RH LiDAR data.

5.4 Results

5.4.1 Perceived effectiveness of sandscaping

This section draws upon findings from multiple open-text survey questions and interview transcripts, that reveals the range of opinions amongst Bacton and Walcott residents on the effectiveness of sandscaping. ‘Effectiveness’ is considered by local residents in terms of the ability of the scheme to protect from the risk of coastal erosion and flooding, but also includes residents’ observations of the scheme (how it is functioning, whether it is functioning as expected, and effects over time). Table 5.1 lists the themes of perceived effectiveness expressed in the survey and the number of respondents that mentioned each theme. Table 5.2 presents thematic codes relating to perceived effectiveness expressed in interviews. Themes are not mutually exclusive in both sets of data, with multiple themes referred to by a single participant.

Table 5.1 Thematic analysis of answers across the survey's open-ended questions, summarising themes which relate to perceived effectiveness of the sandscaping scheme. The different initial codes (column 2) are grouped together according to theme (column 1). Themes are ordered by frequency of appearance amongst survey answers. Questions asked include; *'Why do you think the sandscaping scheme will impact you and your village positively or negatively in the future?'*, '*Has the sandscaping scheme altered your views on how coastal change (i.e. coastal erosion and flooding) could be managed in your village?'* and *'What coastal management, if any, do you think should happen in your village in 15-20 years, which is after the projected lifetime of the sandscaping scheme?'* (Table: I Cotton).

Perceived effectiveness – survey findings		
Theme and response rate	Codes/ theme description (similar codes grouped together)	Example quotes from survey
Evidence it works **(31% of respondents expressed this theme)**	Sand building up, altered beach, feel protected, not experienced any flooding or erosion, less storm damage, technology working, can monitor effectively, better solution to hard defences	*"There have been a similar number of storms since, but none have resulted in flood damage"* *"It appears to be doing what was intended"* *"sandscaping has been a successful (so far) way to manage erosion, because it works with nature rather than causing problems elsewhere as other methods have done"*
Hard defences would have been better **(26%)**	Doesn't fully protect coast, stop cliff erosion, hard defences sturdier, sandscaping not fully effective, need further defences, not implemented successfully, only partially works	*"Still believe rock barriers like Sea Palling are the best solution"* *"The only way to fully protect Bacton/Walcott and the gas terminals is to build proper reefs. Pumping sand onto beach is a pointless task"* *"sandscaping did not work in my view - although saving flooding maybe twice. Reefs like Sea Palling has seem to work better."*
Doubt sandscaping will last full 20 years **(23%)**	Lots of sand gone, won't last	*"We have not had any flooding/ extreme high tides so it has not been proven"* *"Not sure how it will look in 5-10 yrs + how it will effect erosion as I was told it only lasts 10 yrs!"* *"Not sure it will last as long as it is supposed to, high tide is already splashing over the top"* *"I need a lot more convincing as two years on I am already concerned and we were told it would last 20/25 years"*

Observed drop in sand on beaches **(16%)**	Sand gone from beach / washed away / sand disappearing / might not come back / reduced protection /	*"Now that all sand which was pumped ashore has gone…If they continue with this pointless project, then all the same issues will return"* *"Unsure if the recent loss of sand will return or if it is just offshore"* *"Most of the sand put to protect Bacton/Walcott has now gone after a short time of protecting"*
Sand needs topping up (14%)	Needs topping up / needs funds to maintain	*"I think the sand will need to be topped up as we have lost a large amount since it was completed (2019)"* *"It helps and should be topped up"* *"It will need to be maintained e.g. Topping up"*
Changed opinion on sandscaping (5%)	Not aware of sandscaping previously, didn't know would work on this scale, initially sceptical, changed opinion, increased knowledge	*"Always felt there was little could be done, showed me solutions are possible"* *"Didn't think sandscaping would work at all, but works in the short term as wave break further out to sea"* *"I was sceptical about scheme because sand shifts all the time but it seems to be working".*

Table 5.2 Thematic analysis of interview data on perceived effectiveness. The table lists parent codes (column 1) and child codes (column 2) relating to the theme of perceived effectiveness expressed by interviewees. Column 4 provides a brief description of each child code, and column 3 details the number of interviewees which expressed that theme (Table: I Cotton). As outlined in section 4.3.3, it was not possible to record (and therefore transcribe) one Happisburgh resident and one Bacton resident walking interview due to weather conditions, and so coding totals reported in this chapter do not include the walking interview from Bacton (i.e. coding percentages in Table 5.2 are out of 21 rather than 22) (Happisburgh interviews are not reported on in this chapter).

Perceived effectiveness – interview findings			
Parent code	**Child codes**	**%**	**Code description**
Perceived effectiveness	Present day	95%	**Positive**: Working well / created sand bar / breaking waves / sand will come back **Negative**: Loss of sand / groyne's resurfacing / needs maintaining/topping up to be effective
	Future effectiveness	57%	Not had big storms yet / untested / unsure it will last 20 years/ sand loss rate too fast to last 20 years
	Hard defences	29%	Perceived effectiveness of hard defences / need hard defences to support sandscaping
Communication	Communication mis-understandings	29%	*3.1.1 General sandscaping misunderstandings* (Beach access and safety, sand martins, wind-blown sand) weren't

		told wind-blown sand would happen / not told when beach access closed / affects tourism/trade
	43%	*3.1.2 About beach profile* Confusion/ surprise about how beach profile changed post-implementation in 2019, and what was expected. Lack of information on this.

The most frequently mentioned view by survey respondents (31%, Table 5.1) is that sandscaping is working effectively, which predominantly relates to the fact that there has been no observed flooding or erosion in the two years since the scheme was implemented, despite storms occurring during this period. In interviews, the fact that waves are breaking further out to sea, a sand bar has formed, and water is subsequently shallower, were all commonly discussed amongst those with a positive perception on the effectiveness of sandscaping:

> *"When there's a northerly gale, a lot of the energy is taken out of the power of the sea before it gets to the seawall. And so it's quite gentle by, in respect to how it used to be, you know, it would come up against the wall and slam against the wall all over the top, whereas now it's breaking on that sandbar that's out there. And I think that's what it's supposed to do"* ~ Bacton resident

On the other hand, there are some residents that are sceptical about the effectiveness of sandscaping, which principally relates to the observed decline in the amount of sand on the (dry) beach at Bacton and Walcott. For example, 16% of survey respondents explicitly mentioned seeing a reduction in sand, some commenting that the amount is "*most*", "*so much*" or "*all gone*". Meanwhile 14% of survey respondents called for the amount of "*lost*" sand to be "*topped up*" on the beach, in order to last its expected lifetime and to restore the beach profile level to the volume of its initial placement in 2019. Interview data confirms that the reduction in sand on the beach – observable through objects such as groynes resurfacing over time – is the primary reason for doubting sandscaping's effectiveness, with some expressing surprise at the loss of sand. This suggests that some residents expected the placed sand to remain on the beach and perceive a reduction in sand as evidence sandscaping is not working to prevent coastal flooding or erosion.

> *"So you're back down to the walkway. That was when it was originally, that was 3-4 foot under sand, the groynes are all showing again now. They weren't supposed, you were never supposed to see them again"* ~ Walcott interviewee

Interestingly, while some residents are reassured when witnessing sand 'reappearing' after a drop in beach sediment volume, others remain sceptical about the scheme. This highlights the same observation is being used by different residents to reaffirm people's understandings of the scheme:

> *"So in the meantime, obviously I took a lot of interest in what was going on in Walcott, and of course there as well, the water took the sand away and it brought it back, bought away. I thought it's working, brilliant"* ~ Walcott interviewee

> *"You know local people say 'oh, but it'll all come back again', you know, 'that's what the tides do'. And it, you know, but it always did do that. And so when they put so much there, I mean before when the tides were out, you could see all the groynes and everything. So for it to have covered the groynes up a huge amount, where has it all gone again? (laughs) I mean has it all gone back down to Yarmouth where they brought it from?"* ~ Bacton interviewee

The observed drop in sand on Bacton and Walcott beaches also appears linked to the opinion held by 26% of survey respondents that hard engineering defences would have been more effective. One respondent conveyed the drop in placed sediment as evidence that sandscaping is a "*pointless task*", meanwhile another stated that sand would always get "*washed away*". There is a perception by some residents that on its own, sandscaping is not a fully effective coastal management strategy, and that “*further measures*” such as hard defences are needed, together with sandscaping. Interview data additionally suggests that hard defences are trusted partly given they have been used on the coastline for a long time. This indicates that the novelty of sandscaping could contribute to doubt over its effectiveness:

> *“But obviously seawalls are clearly very effective because they've been there for many, many decades and, so although they are the most effective, yeah, they aren't, they are a bit unsightly (laughs)”* ~ Bacton resident

> *“I remember it used to knock blocks out the seawall at the top, but now it doesn't, because they double skinned it. But whether or not, that’s effective to a point isn’t it? And sandscaping is not the answer, it’s like to build sandcastles on the beach (laughs) and sit and watch it fall away”* ~ Bacton resident

Nearly a quarter of survey respondents (23%) are sceptical that sandscaping will continue to work for 15-20 years (which is the official expected lifetime of the scheme as communicated by the local council (NNDC) and RH (2018a), who designed the scheme). Table 5.1 reveals the varying timescales of effectiveness perceived by survey respondents (e.g., anywhere between 10 and 25 years). Interestingly, this perception is not limited to survey responses with an overall negative perception of sandscaping. For example, some residents who were highly positive about the scheme and convinced it is working in the present day, remain doubtful that sandscaping will continue to work into the future, because of the reduction in volume of sand. Interview data indicates more widespread doubt (57% of interviewees) about whether sandscaping will continue to be as effective in 20 years, than was apparent in the survey data (23% survey responses). For both survey and interview data, this view is expressed both by those positive and negative about the scheme. There is a perception that the sandscaping scheme, 2-3 years in at the time of the survey and interviews, is as of yet untested by extreme weather:

“I don't think it's really been. I mean, I think as a protective, as extending the life of the seawall, it's absolutely effective. And as improving the amenities of the beach, it's been effective. In terms of flood risk, I don’t know it's been properly tested yet because we haven't had a big surge (laughs)” ~ Walcott resident

“But these guys who were seeing this sand as it is now thinking ‘That's superb, brilliant, job done’, little do they know that if the wind and tide clicks, that’s gone. And if you look now to when they first put it in, its disappearing and there's only one way It can go pretty much, and it goes back to where they got it from, it just goes up the coast” ~ Bacton resident

Much of this concern about the effectiveness of sandscaping in the future relates to extrapolating the rate of sand loss seen in first 3 years over to the next 15-20 years.

“No I don’t, really, because how, it's supposed to last for 20 years, and if you look at how much that has already been washed away and we haven't really had spectacularly high tides or any storms to speak of” ~ Bacton resident

“And so the way it's going at the moment, when it's all gone, it's hard to believe that it's still going to all be there in 15 years’ time”. ~ Bacton resident

Overall, as shown in Table 5.1 and 5.2, the data reveal a divergence between residents that perceive sandscaping as effective, and those that do not, alongside a range of observations that residents draw upon to justify their opinions, and perspectives of sandscaping into the future.

5.4.2 Geomorphological changes

This section explores the geomorphological changes post-sandscaping that residents report in the survey and interview data. Analysis of coastal LiDAR data at Bacton and Walcott, in terms of the movement of sediment between 2018-2022, reveals a similar trend as observed by local residents. Panel (A) (Bacton) and panel (B) (Walcott) in Figure 5.1 shows the cross-shore winter beach profiles in the year before sandscaping (2018, dotted black line) compared to the first (2019, orange line), second (2020, blue line), third (2021, purple line) and fourth (2022, green line) year since implementation.

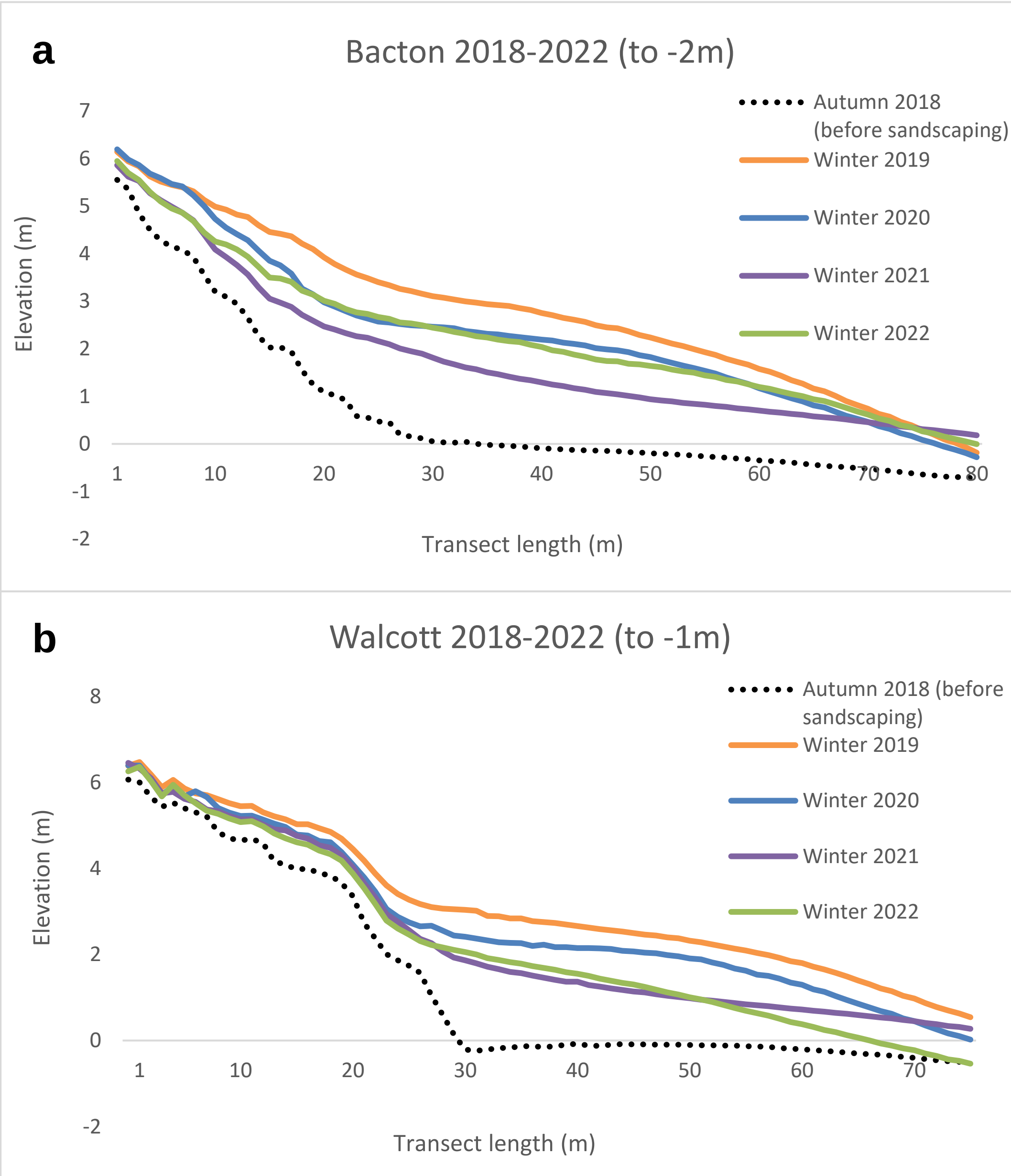


Figure 5.1 Beach profile elevation changes at Bacton (panel (A)) and Walcott (panel (B)) from 2018-2022, comparing changes on the upper shore and foreshore (to a depth of approximately -2m) before (dotted black line) and after sandscaping (year 1 in orange, year 2 in blue, year 3 in purple and year 4 in green). Transects begin at the sea wall at Bacton and Walcott, and transect length increases seaward, as plotted on the x-axis. Panel (A) and panel (B) show secondary data from the ACM Programme (2022) (Figure: I Cotton).

The foreshore is the area between the average high water mark at neap tide (MHWN) and at low tide (MLWN) i.e. what is often considered to be the beach – the EA (2011) calculated this to be +1.05m – -0.75m for Bacton, in their 2011 coastal flood boundary conditions dataset.

Panel A and B in Figure 5.1 illustrate the initial, dramatic effect of sandscaping increasing beach elevation and width. Where in 2018 pre-sandscaping, there was very little upper 'dry' beach (the area above average high water mark at neap tide (MHWN)) at Bacton and Walcott, after sandscaping was completed in 2019 the beach was several meters higher and much wider. Elevation dropped slightly in 2020, compared to 2019. From 2020 to 2022 the elevation in the upper 'dry' beach (first ~50m of transect length) continued to decrease i.e. the volume of sediment on the upper 'dry' beach continued to decline. Therefore, as similarly observed by residents, there has been a decrease in placed sediment on the upper 'dry' beach, in the first four years since sandscaping was implemented. However, in 2022 a slight increase in elevation can be observed, largely at Bacton but also at Walcott, revealing that sediment levels are fluctuating year to year, and not consistently declining post-sandscaping. In 2019, sandscaping moved the location of the foreshore approximately 50m offshore (panel A Bacton and panel B Walcott) and there has been little change in elevation at this point post sandscaping (approximately 75m along the transect).

Meanwhile, Figure 5.2 uses secondary data from RH and reveals sub-tidal changes in beach profile after sand placement (to a depth of approximately -9m) in the first (2020, blue line) and second (2021, yellow line) year of the sandscaping scheme. Overall, changes between 2020 and 2021 reveal a decrease in elevation/sediment in the upper subtidal zone just below the foreshore (of approximately -1m to -4m elevation) occurring approximately 100m to 200m along the transect, and an increase in elevation/sediment between approximately 200m to 350m along the transect (Figure 5.2, panel A Bacton and panel B Walcott). Therefore, while Bacton and Walcott have overall seen a decrease in sediment on the upper shore and subtidally just below the foreshore from 2019-2022, in the first two years since sandscaping was implemented there was little change in the new location of the foreshore (i.e. where the 0m sea level is located), and an increase in elevation/sediment in the lower subtidal zone. Whilst the source of the accreting sediment in the lower subtidal zone is unknown, it may in part be migrated sediment from the upper 'dry' shore and/or upper subtidal. Both villages show a similar trend, although changes in sediment for the area sampled at Walcott (panel B) are larger than those at Bacton (panel A).

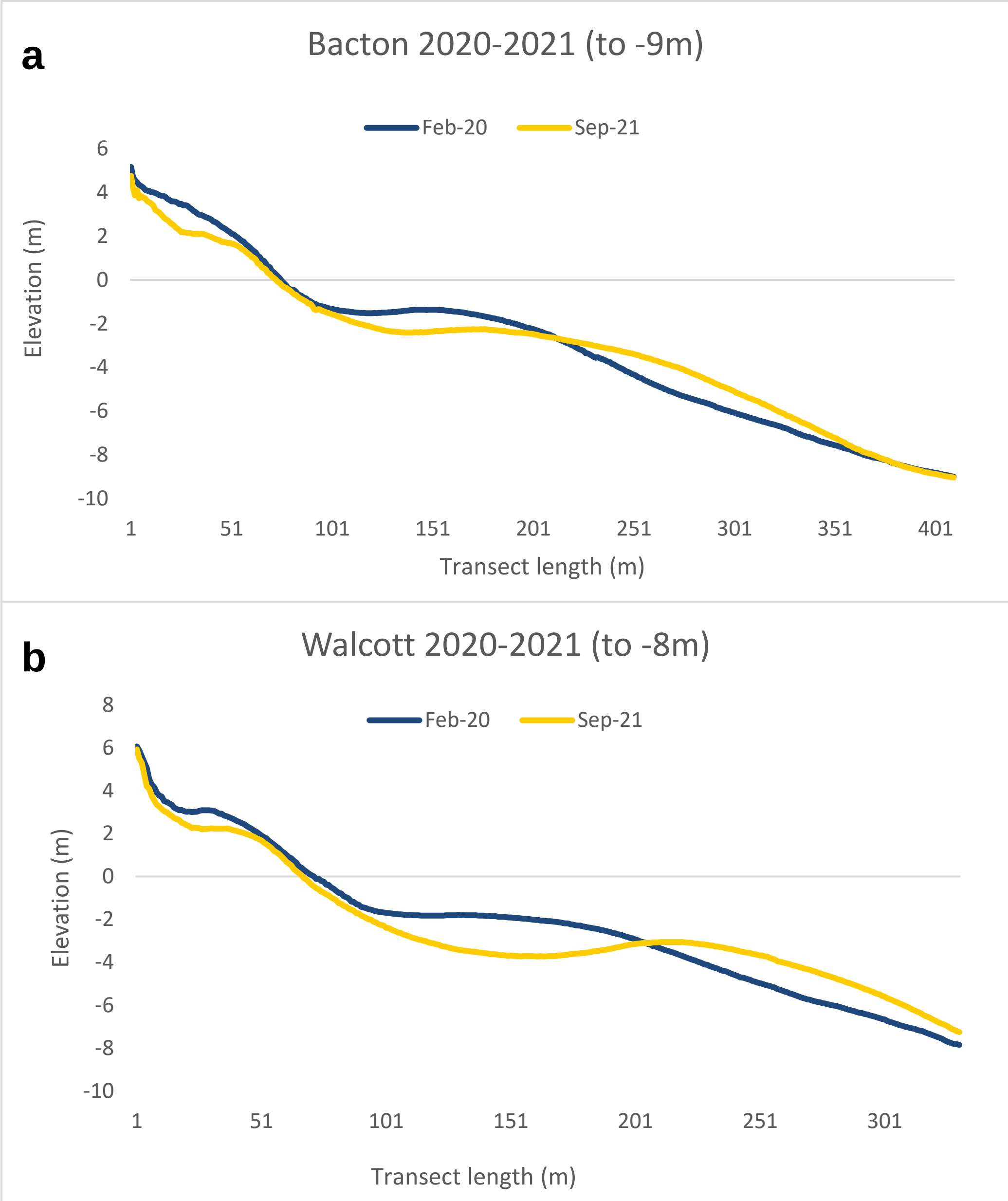


Figure 5.2 Panel (A) and panel (B) reveal beach profile elevation changes at Bacton (panel (A)) and Walcott (panel (B)) for the timeseries 2020-2021, which corresponds to the two years after implementation of the scheme. Panel (A) and panel (B) sample to a depth of approximately -9m, revealing changes in the subtidal zone. Transects begin at the sea wall at Bacton and Walcott, and transect length increases seaward, as plotted on the x-axis.; panel (A) and panel (B) are secondary data from RH (2022c) (Figure: I Cotton).

5.4.3 Impacts of the sandscaping scheme

Analysis of survey questions on the impacts of sandscaping reveal that for many residents, sandscaping provides several positive impacts, beyond the principal positive impact of (thus far) no flooding or coastal erosion. Table 5.3 lists the different impacts reported by respondents, grouped into main themes. Impacts were not mutually exclusive; that is, respondents reported positive and/or negative impacts, or combinations of these; and some respondents reported no impacts.

Table 5.3 Reported positive and negative impacts of the sandscaping scheme from residents in the survey. Impacts are grouped into codes of similar themes. Impacts reported as positive are presented first (in blue shading); negative impacts are shown in orange shading. Impacts reported both positively and negatively (for example increased visitors to the village) are listed twice. Questions asked include; *'Have there been any positive impacts of the sandscaping scheme to you and/or the village you live in? If yes, please specify what these positive impacts are'* and *'Have there been any negative impacts of the sandscaping scheme to you and/or the village you live in? If yes, please specify what these negative impacts are'* (Table: I Cotton).

Impacts of the sandscaping scheme		
	Main theme (impact)	**Codes**
	No flooding/ erosion	-No flooding or erosion events and associated physical impacts (property damage, inundation, house shaking, sea spray, overtopping of sea wall, cliff collapses).
	Bigger/ sandier beach	-Restorative benefits of having a wider, bigger, sandier beach. -More attractive beach and coastal scenery. -Change (reverting back) to how beach used to look in the past.
	Recreational opportunities	-Recreational benefits, with calmer sea for swimming, kayaking, sunbathing, bird watching, and new shallow areas in the sea. -Cleaner beach /less rubbish washed up.
	Physical access/ safety getting on/off beach	-Permanence of access for different parts of beach at all times of day (e.g. including during high tide). -Now possible to walk between villages along the coast. -Improved physical access and safety in getting on/off beach for wheelchair users/ users with reduced mobility.
	Reassurance/ peace of mind	-Mental health benefits of greater reassurance, peace of mind, and reduced anxiety about flood or erosion risk and impacts.
	Increased property value	-Perceived financial benefits from increased property value and the village being a more desirable place to live. -Not incurring financial expense from flood or erosion property damage.
	Coast road stays open	-The main road connecting the villages of Bacton and Walcott to other parts of the coast does not flood, providing reliability for transport and access.

	More visitors and trade	-More visitors to beach, more trade to shops, cafes, pubs. Village thrives and has financial viability.
	More people using beach	Greater numbers of tourists and visitors to the beach.
	Impact of more visitors	Impact of more visitors: - Cars (traffic, inconsiderate parking blocking houses and roads, visitors not using car parking provided, nowhere to park in village). - Litter (more dog waste and other litter). - Antisocial behaviour, petty crime.
	Wind-blown sand	-Wind-blown sand into gardens, open windows, car screens, blocking gutters/ drains, damage to outdoor equipment, and depositing around the village. -Required locks to be taped over and financial cost and stress to clean-up houses and gardens.
	Change in physical access to beach	-Access to beach is harder due to slopes, the loss of concrete path along the beach by sea wall makes it harder to walk for some (prams, wheelchairs). Some areas now closed. -Change in aesthetic to beach (appears scruffier). -Safety issues of groynes partially or fully submerged by sandscaping.

Survey respondents spoke about the restorative benefits of having a superior sandy beach and ‘coastscape’, as well as better beach access for recreational activities such as walking and swimming at all times of the day, rather than just at low tide. A few survey respondents conveyed enthusiasm that the coast is “*back to its ‘old’ sandscape beach*”, the village is “*surviving*” again, and the coast road remains open, strengthening local residents’ sense of place of their locality. Respondents also reported psychological benefits (such as reduced anxiety) from the reduction in coastal flood or erosion risk – the significance of this is explored further in Chapter 7. Lastly, residents reported financial benefits of no property damage from storms, higher house prices, and more visitors (and thus trade) to the village.

Although reported impacts were largely positive, and 32% of survey respondents gave no negative impacts, the remaining respondents did report negative impacts. These included wind-blown sand, the practical impact of more visitors, and beach safety/access issues. For some wind-blown sand was an inconvenience (for example depositing around village, blowing through windows, requiring locks to be taped over), but for others it has led to damage and financial expense to clean up properties and gardens. This demonstrates how impacts from the sandscaping scheme have been experienced to differing extents amongst local residents. Some impacts, for example the impact of more visitors to an area, was reported positively by some (e.g., more trade, more popular village) but negatively by others (e.g., traffic, accessing beach). This indicates that the experience of impacts, and whether they are perceived as positive or negative, vary at an individual level.

5.4.4 Trust in, and communication from, policymakers

Survey respondents were asked about trust in local coastal management decision-making (n=73). Figure 5.3 shows a clear range of opinion amongst respondents on whether coastal change is managed appropriately for their village: 25% respondents either strongly or partially disagree with this statement (and of this, 14% strongly disagree with this statement), and 29% neither agree or disagree. Meanwhile, 47% of residents strongly or partially agree that they ‘trust that coastal change is managed appropriately in my village’. This indicates that while views are mainly neutral or positive, there are a sizeable number of negative views on local coastal management decision-making.

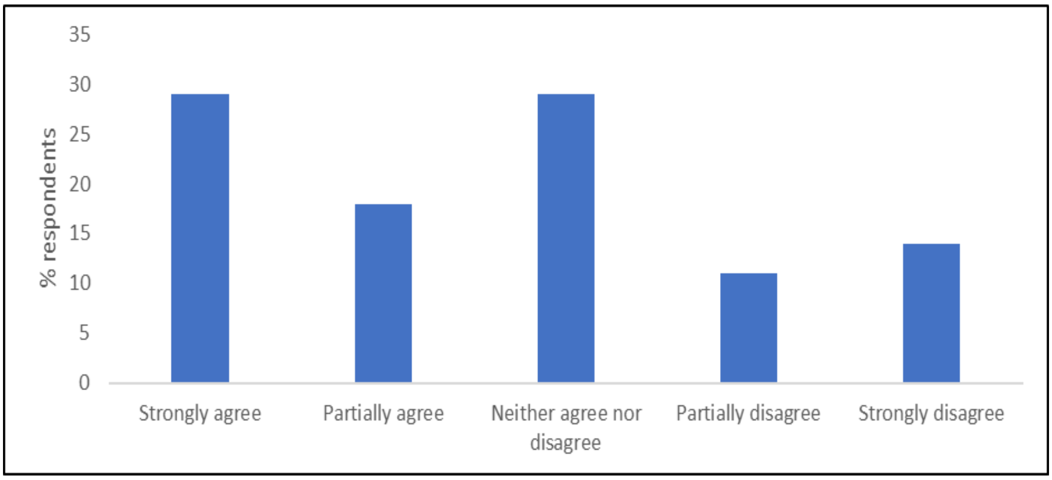


Figure 5.3 Responses to survey question on trust in coastal management; 'I trust that coastal change is managed appropriately in my village' (n=73) (Figure: I Cotton).

The interview data with local residents provides further insight into perceived trust with different types of policymakers (Table 5.4). For some Bacton and Walcott residents, there is a degree of scepticism regarding what policymakers say in terms of motive. Residents spoke in interviewees that local and national policymakers are driven by funding and finance considerations, rather than what coastal management is effective or needs maintaining. Residents also raised doubt on how truthful, genuine, and accountable policymakers are – this was in particular about policymakers at a national level. The theme of trust is further explored in the context of Happisburgh in Chapter 6, bringing in the perspectives of Happisburgh residents and coastal policymakers on managing coastal change, and the relationship between local residents and coastal policymakers.

Table 5.4 Child codes (column 1) relating to the overall theme of trust in policymakers expressed by resident interviewees. Column 3 provides a brief description of each code, and column 2 details the number of interviewees which mentioned that theme (Table: I Cotton). As outlined for Table 5.2, coding percentages are out of 21 rather than 22, due to one walking interview where it was not possible to record or transcribe.

Trust in policymakers – interview findings		
Child code	% interviewees	Code description
4.1 Motive of policymakers	52%	Scepticism of motive/ Vested interests/ official timeframe / actions / genuine words
4.2 Strained relations with policymakers	67%	Scepticism of sandscaping due to mistakes of past coastal interventions / strained relations / engagement going nowhere
4.3 Good relationships with policymakers	24%	Anecdotes of good relations/ experiences between residents and policymakers, good levels of trust

Only a minority of interviewees (24%) expressed positive perceptions of relationships with policymakers on coastal management (such as trusting their judgement and the information provided). At a local level, trust in policymakers was often described by resident interviewees with regards to strained relations in the past (for example the extent to which coastal defences are maintained), a lack of meaningful consultation with local residents on the choice of sandscaping as a coastal management strategy (public participation in coastal decision-making is explored in greater detail in Chapter 6), and a lack of maintenance on safety or access issues to the beach after sandscaping:

> *"Sometimes it's like going round in circles because nobody will take responsibility. And they were saying it was the sandscaping scheme, which was obviously provided by the gas works and stuff, but it's trying to find someone actually say 'yeah, OK we'll be responsible for aftercare'. Just doesn't happen"* ~ Bacton interviewee

> *"One of the things that I thought they were very disingenuous about was, erm, some people like the RSPB, giving them guidance on the netting they should put up. And they, either they did it deliberately or they didn't supervise it properly, but*

the whole of the Cliff got netted. People were kind of ripping it down because they were so upset about it, and when you spoke to them and they said, 'well, we were never given that advice' and I said 'well, you were because I read the report!'" ~ Bacton interviewee

The interview data also revealed there are ranging views on the overall quality (e.g. availability) of information from local policymakers whilst sandscaping was being implemented. This suggests that residents' access to the public communication outlined in section 5.2.2 varied, in the months and years prior to the implementation of sandscaping in 2019. However, where there was strong agreement amongst interviewees is an interest in receiving more information about sandscaping and how its evolving, as it has implications for what coastal management follows sandscaping in 20 years' time. Perceptions of coastal management post-sandscaping are explored in greater detail in Chapter 7.

"I think generally local people need reassurances because they can see what appears to be a massive amount of money being spent, and whilst that's not being taken from them, you still want to believe that it was a valid investment. I think it kind of needs explaining as a process, like this is what we expect to happen, This is as expected, do not be alarmed. it seems like quite a long term plan, but that will go in a flash, and we need to know what happens next!" ~ Bacton interviewee

"It would be nice to be getting some kind of feedback about you know, how successful, those that had planned the scheme as it were, feel that it's been, is it doing what they expected, is the engineering of it kind of worked how they expected and the like. Because I think just recently there's been a little bit of doubt, you know?...there's quite a bit of sand that suddenly gone up at Ostend, and people were a little bit worried about, is the lifespan of the scheme going to be what it originally was so, so I think there's still. There's still room for a bit more communication there" ~ Walcott interviewee

Local residents conveyed being very open to what form information about sandscaping and coastal management takes, but are more concerned that the source of information is independent and evidence-based. There are some differences of opinion on what types of institutions are perceived as credible:

> *"But again, yeah you want something that's independent, and not, that's the key thing these days is that, I think people want to trust a source of information".* ~ Bacton resident

> *"I think people trust it more from the Council. And because obviously we receive communications from them about other things and. As much as we can trust anybody in authority at present! Then we have to, we have to work In partnership with council, don't we, because there's certain things we need from them, so I think If it's got this sort of NNDC stamp on it then it has a level of authenticity that most people would would buy into".* ~ Bacton interviewee

> *"I would like that to come from some group that doesn't have an affiliation to whoever decided on the sandscaping".* ~ Walcott interviewee

5.5 Discussion

5.5.1 Perceived effectiveness of the sandscaping scheme

Research question 2a seeks to explore resident perceptions of sandscaping, and this chapter finds that different views of effectiveness are apparent amongst Bacton and Walcott residents. Reflecting on the first few years of the scheme (two years at the time of the survey and three years for the interview data), some perceive it to be working (largely due to no flooding or erosion and a longer beach/ presence of a sand bar) and some do not (due to a decrease in placed sediment on the beaches and objects such a groynes now resurfacing). Diverging views amongst local stakeholders and concerns over effectiveness have been found elsewhere in other coastal contexts, e.g., of smaller-scale beach nourishment (Prati et al., 2016) and of managed realignment (Roca and Villares, 2012). The contrasting perceptions at Bacton and Walcott indicate different understandings amongst residents on how sandscaping is expected to evolve and change the local coastline over time. In answer to research question 1a (investigating beach profile changes), the LiDAR (elevation) data of the coast shows that although there has been a decrease of sediment on the upper (dry) beach and the first ~100m of the subtidal in the first two years of the scheme, sediment stayed at similar levels on the foreshore (between high and low tide) and increased in the lower subtidal, where it will still contribute to reducing erosion risk. That local residents observed the drop in beach volume on the upper beach, and used this observation to inform perceived effectiveness of sandscaping, highlights the link between geomorphological change and social perceptions in this empirical context, which is illustrated in the conceptual framework diagram (section 3.5) by the connected 'social' and 'environmental' boxes.

The geomorphological observations of beach profile explored in this chapter match the modelling of the scheme (NNDC, 2022b) indicating that sand would decrease on the beaches over time, and that sand would migrate seawards after storm events. Modelled expectations of cross-shore sediment movement were for placed sediment to migrate from the upper 'dry' shore to the foreshore (RH, 2022a), which is observable in Figure 5.1 from 2019-2022. Panels A and B of Figure 5.2, and residents observations in section 5.4.1, confirm the reappearance of subtidal sand bars on the frontage, similarly found by RH in their geomorphological analysis, who argue that sediment which has migrated to form subtidal sand bars is likely to remain rather than be lost offshore (RH, 2022a). This suggests that sandscaping is working as expected in the first few years of its lifetime, as cross-shore sediment migration matches the modelled expectations of the scheme (research question 1), and subtidal sand bars will induce breaking of waves further out to sea, rather than at the sea wall, offering greater protection during storms. Identifying the source and direction of sediment migration cross-shore and alongshore (in other words, attributing beach profile changes to sandscaping), is very difficult given the limited LiDAR data, and is not possible without analysis of the sediment, which is beyond the scope of this study. For local residents, some of the profile changes reported here would be difficult or even impossible to observe from land, given the foreshore zone is under the mean high-water mark (i.e. below high tide and only periodically observable) and the subtidal is covered by water and largely unobservable. This highlights how incomplete knowledge and understanding of how sandscaping works and the changes that have occurred post sandscaping can lead to an opinion that the sandscaping scheme is not working.

The survey and interview data revealed doubt among some residents on the long-term effectiveness of sandscaping (i.e. for a full 15-20 year lifespan). Even those residents who feel the scheme has been effective to protect from erosion and flooding in the first 2-3 years expressed some scepticism that it will continue to be effective in 20 years. Observations of a drop in sand volume on the upper (dry) beach appear to contribute to this perception. This raises a question on local residents' understanding about how sandscaping would change the local beach at Bacton and Walcott over time. As mentioned in section 5.2.2, the local council (NNDC) organised several community engagement events before and during the implementation of the scheme, which included a Local Liaison Group, village drop-in events, and public information boards at Bacton and Walcott beaches (NNDC, 2017), alongside reporting in the media (e.g. BBC, 2017). Despite this, the scale of doubt (almost 1 in 4 survey respondents and over half of interviewees) about the long-term effectiveness of sandscaping over the next 20 years suggests that diversity of opinions may be influenced by several factors, as highlighted in literature. This includes different perceptions of nature-based solutions (Anderson and Renaud, 2021) and on the goal of adaptation (Dilling et al., 2019). Further, studies specifically in the context of coastal management have shown different risk perceptions (Prati et al., 2016; O'Donnell, 2019) and perceived responsibility (Clément et al., 2015) of coastal change amongst coastal populations. More broadly, there is also long-standing research on public scepticism of expert knowledge, both within and outside of environmental policy and issues (Sjöberg, 1999; Fairbrother, 2017). This illustrates a challenge for policy-makers in local stakeholder engagement where there are many diverse opinions relating to coastal management, and numerous potential factors contributing to held opinions.

Presenting data and keeping local residents regularly updated with how beaches will change, could be one way for coastal managers to answer questions and engage residents on the changing profile of sandscaping, which will evolve over time. This could be further explored in future research, to consider how and why different aspects of information and forms of communication are trusted or not, are how they are interpreted. In particular, findings in section 5.4 suggest that policymakers could be more explicit in public communication about how beaches will change visually, and that changes in beach profile while sandscaping is in place, such as fluctuating sand levels and groynes resurfacing, is to be expected and will not reduce the overall effectiveness of the scheme. Figures 5.1 and 5.2 reveal that the greatest cross-shore sediment changes have occurred around mean sea level, as similarly found by RH (2022a), and the Zandmotor scheme, where analysis of the first five years (Roest et al., 2021) saw minimum movement beyond -8m below mean sea level, and greatest activity in the intertidal zone.

Interview data reveals that nearly all residents would like to be kept updated about how sandscaping is performing and evolving. Figure 5.1 reveals that the greatest change in the volume of sediment occurred in the first year (Winter 2019), which concurs with analysis by RH (2022a) that cross-shore sediment movement, particularly at Bacton Gas Terminal, is slowing (in 2022), and similarly in the Netherlands, that the most active phase of sediment movement for the Zandmotor scheme was the first six months after implementation (De Schipper et al., 2016; 2021). This dynamic changing profile of the coast highlights that community engagement on sandscaping could continue after implementation, and also presents an opportunity to reinforce communication channels and improve trust (explored in next section, 5.5.2) between residents and local policymakers on coastal management. This appears particularly relevant given the current policy context in the UK, where at-risk coastal villages, such as Bacton and Walcott, have a change in SMP policy to managed realignment in the medium term (from 2025), which will require time and dialogue between policymakers and local residents (themes discussed further in Chapters 6 and 7).

5.5.2 Trust in coastal management at Bacton and Walcott

This chapter's findings also show a divergence in opinion amongst residents on the extent to which they trust how coastal change is managed in their village. A quarter of survey respondents stated that they felt some or strong distrust (with 29% stating neutral responses to the question of trust). Whilst survey data highlighted almost half of respondents partly or strongly trusted coastal management for their village, a notable minority of residents have low levels of trust. The interview data highlighted there is greater distrust for national rather than local coastal policymakers, but also revealed negative perceptions at a local level on the financing of sandscaping, ongoing maintenance of the scheme, and prior consultation with local residents (views on consultation and coastal management are discussed in greater detail in Chapter 6). Community distrust of coastal management has long been highlighted, such as Myatt et al., 2003's study on local community perceptions of proposed managed realignment in Freiston shore, Lincolnshire. Meanwhile, recent research on other coastal communities that face high erosion risk, such as Hemsby (also on the Norfolk coast), similarly found that issues of trust between residents and policymakers were a challenge for, and high trust an important precursor to, community engagement on coastal adaptation (EA, 2021a). Low trust in how coastal change is managed can have implications for future coastal decisions, potentially acting as a barrier to public engagement and to the participation in, and acceptance of, longer-term adaptation strategies (Milligan et al., 2009; O'Riordan et al., 2014; Anderson and Renaud, 2021). Furthermore, trust between communities and policymakers can be damaged where there is high staff turnover, indicating that trust is built at an individual level but can be difficult to maintain (EA, 2021a). Taken together, all of the above highlights the significance of building trust and relationships between policymakers and local communities, and that it is still a relevant objective in managing coastal change (EA, 2021a). Trust in institutions is included in Figure 3.3 as a factor influencing 'capacity to adapt', which is one of three adaptive capacities present in the conceptual framework. In this empirical context, trust appears to be a significant factor shaping residents' perceptions of coastal change.

For Bacton and Walcott residents, it is unknown what coastal management will happen after the lifetime of the sandscaping scheme. As a novel, untested, nature-based solution, the actual lifetime of the sandscaping scheme is uncertain, with its 15-20 year estimate only serving as a guide. Survey responses showed a range of resident perceptions on how long the scheme could last (from anywhere between a few years to 25 years), with no geomorphological evidence available yet to confirm the lifetime of the scheme. Meanwhile, a 10-year evaluation of the first mega-nourishment scheme (the Zandmotor scheme in Holland), implemented in 2011, suggests it is likely to last longer than its official 20 year estimate, because the loss of sediment observed in the first decade of the scheme is lower than expected (Huisman et al., 2021). This further highlights the uncertainty of the longevity of sandscaping as a coastal management strategy; it is likely to be unique to each coastal context, which raises an important question for coastal managers on when and how to prepare for future coastal risk. The perspectives of Bacton and Walcott residents and policymakers on coastal management post-sandscaping is returned to and explored in detail in Chapter 7. This chapter has revealed varying expectations amongst residents across Bacton and Walcott of when sandscaping will end, and differing levels of trust in the coastal management process for their villages. The current flood and coastal erosion strategy for England (EA, 2020, p.49) calls for "*local leadership and support from the local community*" in building resilience to future coastal change, but an agreement on what this looks like in practice may be extremely difficult. The launch of the £36 million CTAP project by Defra (2022) may be an opportunity to work through multiple perspectives and rethink how future options of coastal change can be considered and planned for by at-risk coastal areas. Perspectives of, and implications for, the CTAP project, are explored next in Chapter 6.

5.5.3 Social impacts of sandscaping

Research question 2a also seeks to understand the social impacts of sandscaping, and survey responses from residents highlight a wide range of both positive and negative impacts, in the first 2-3 years of the scheme. Sandscaping has provided multiple positive impacts to the local villages, but a uniquely positive experience has not been felt or reported by all. Across the social data presented in this chapter, residents think differently about the scheme despite drawing upon the same observation or impact. For example, the contrast between residents who felt sandscaping is not working because of the reduction in sand and those who felt it is working despite it, or residents who felt sandscaping was positively impacting their village because of more tourists and those who perceived this as a negative impact. Longitudinal work, or more in-depth qualitative work, such as interviews or focus groups, could be conducted later in the lifetime of the sandscaping scheme, to compare how and why residents' perceptions and experiences change over time. This could be analysed in conjunction with a study on mineralogy, to explore where placed sediment from the scheme has migrated along the coastline.

The role of an individual's values in influencing different perceptions of beach nourishment has been found elsewhere (Prati et al., 2016), and the findings presented in this chapter suggest there may be deeply engrained beliefs, which alongside personal experience, shape an individual's perception of a coastal management strategy and its effectiveness. This concurs with findings from this thesis literature review (Figure 3.5), that there are a range of factors shaping public perceptions of adaptation and coastal management strategies. For example, D'Souza et al., (2021) found a link between support for hard defences and more conservative political values, while Jones and Clark (2014) highlight the level of trust in institutions, and perceived acceptability of coastal management strategies, correlates with social trust and social capital (further underlying the role of trust already discussed above in section 5.5.2).

The range of social impacts and experiences of sandscaping also further underline the argument by de Schipper et al. (2021) that evaluations of beach nourishment's overall 'effectiveness' needs to consider both social and physical impacts. This appears a relevant learning not just for the implementation of sandscaping, but evaluations of other nature-based solutions, to draw upon social perceptions and experiences, and therefore broaden evaluations beyond effectiveness that also incorporates principles of environmental justice. This is a relevant finding for research question 3, on the relevance of incorporating environmental justice principles into coastal management policy that focuses on resilience. In the context of mega-nourishment at Bacton and Walcott, the survey and interview data suggest that the range of social impacts and perceptions on sandscaping have implications for building the social resilience of communities to coastal change after the lifetime of the scheme (research question 2c, explored in Chapter 7). This is in terms of potentially conflicting preferences for future coastal management, and which is an overlooked component of system resilience in the beach nourishment literature (section 2.3.2).

5.5.4 Perceptions/preferences of 'soft' versus 'hard' engineering

Over a quarter of surveyed Bacton and Walcott residents perceive hard defences to be a more effective coastal management strategy to protect from flooding and erosion compared to sandscaping. This correlates with findings from existing literature (section 5.2.1) on scepticism of soft engineering over traditional hard defences (Roca and Vilares, 2012; Anderson and Renaud, 2021). Examples of hard defences mentioned in the survey are those historically used at this area of the coastline, or those used successfully elsewhere (such as rock barriers, reefs, breakwaters, and a sea wall). Numerous factors could be contributing to this perception, including that sandscaping is relatively novel and therefore seen as uncertain or untested, or, as highlighted in interview data, that hard defences have for decades historically been used at the villages of Bacton and Walcott to manage the risk of coastal change. Therefore in this context, there is a perceived familiarity with hard defences, compared to the novelty of sandscaping. Sandscaping works very differently to hard defences, in that it is constantly changing, partially invisible or submerged by tides, and of a much larger spatial and temporal scale. The issue remains that if sandscaping is being compared like-for-like to how hard defences are engineered (as similarly argued by Anderson and Renaud, 2021), indeed this soft engineering approach could be perceived as less effective. Sand will migrate, as noted by residents in the survey, while hard defences stay put, and thus may be perceived to better protect from coastal risk. This is despite evidence that hard defences can themselves exacerbate erosion, and by suppressing the movement of sediment, can increase the risk of erosion elsewhere along the coast (French, 2004; AECOM, 2012b: Nicholls et al., 2013).

Even residents who perceive sandscaping to be effective also suggest hard defences should be further installed on the Bacton and Walcott frontage, to further protect from coastal flood and erosion risk. Amidst the uncertainty on the perceived lifetime of sandscaping, this indicates that hard defences (either in combination or replacing sandscaping) are seen by some respondents as a more reliable coastal management strategy. It is therefore important that the advantages and disadvantages of nature-based solutions, or any novel strategy, particularly where implemented in places with historically very different management strategies, are included in communication to and discussions with key stakeholders, and as already highlighted, for this engagement to be ongoing (Anderson and Renaud, 2021). For the case of the Bacton-Walcott sandscaping scheme, further exploration of the merit of different approaches to communicating nature-based solutions, from the perspective of key stakeholders, would be an important next step.

5.6 Conclusions

This chapter has found wide differences in perceptions, and notable levels of doubt, on the ‘effectiveness’ of sandscaping at present and in the future, alongside different lived experiences of the scheme and prevailing distrust by some residents about coastal management. This highlights the need for further engagement with Bacton and Walcott residents on how sandscaping is evolving on the coast. This could potentially be through citizen science, that includes residents in ongoing monitoring and reporting change. Keeping residents updated on changes to sandscaping with environmental data and communicating the advantages of nature-based solutions appear relevant in this context, but the diversity and contrast of resident perceptions illustrates deeper challenges for future coastal management planning. There is a need to think through how future coastal change can be planned for, drawing upon multiple social perspectives. In particular, there is a need to consider how residents may engage in varying ways, and how residents' differing views may inform future coastal management. Facilitating this requires further attention, given the greater role envisaged by policymakers (for example the EA, 2020) on UK coastal communities contributing to coastal decisions made in their area.

From a geomorphological point of view, this chapter reveals the coastal system is functioning differently in response to increased sediment from the sandscaping scheme, with the formation of subtidal sand bars and the beach profile taking a more natural shape. Geomorphologically, sandscaping appears to match Kates et al's (2012) description of transformation (section 3.2.3), in that it is innovative, large-scale, and has significantly altered the coastal system. However, in a coastal management policy context where strategies are becoming increasingly innovative or with multiple win-win objectives (such as the use of sandscaping), there is a need to expand how schemes are monitored and evaluated to encompass the broad range of physical, social, and other relevant objectives, in its unique context. Findings here of residents' perceptions and geomorphological observations of the Bacton-Walcott sandscaping scheme indicate that considering nourishment strategies in terms of physical risk alone is not sufficient in measuring overall 'effectiveness'. There are some differences between residents' perceptions of the scheme and geomorphological change. As a case study rooted in the local context of Bacton and Walcott, further research could be conducted elsewhere to understand how perceived effectiveness of adaptation compares in different contexts, either where mega-nourishment is implemented or otherwise.

Therefore, whilst this chapter has focused on perceived effectiveness, it has several findings on trust and engagement between residents and local authorities that have implications for coastal management in the future. This is explored further in the following chapter, in terms of residents perceptions of coastal adaptation, and lived experience of coastal change. Chapter 6 explores this using an environment justice lens, prominent in this thesis' conceptual framework, and does so by expanding scope to include the perspective of residents from Happisburgh, which are considered in relation to the perspectives of Bacton and Walcott residents, and policymakers. This is explored in the context of CTAP, the current policy programme on coastal adaptation on the North Norfolk coast (2023-2027), and which will involve discussions between local residents and policymakers on coastal adaptation.

Chapter 6. Environmental justice in coastal adaptation: insights from Happisburgh

6.1 Introduction

As highlighted in section 2.2.2, flood and coastal risk management policy in England increasingly promotes coastal adaptation plans that are co-developed by local communities themselves. Focusing on the village of Happisburgh, this chapter adopts an environmental justice lens to explore local resident and policymaker perspectives of managed realignment, that may have a bearing on the implementation of local coastal adaptation plans. This chapter primarily answers the second part of research question 2 (2b), which explores past, present and future perceptions and lived experiences of coastal change at Happisburgh. Whilst focusing on the views of Happisburgh residents, views from adjacent coastal villages (Bacton and Walcott), alongside coastal policymakers, are also reported on here, to examine the variety of perspectives on managed realignment. These perspectives are presented alongside maps and calculations of recent (2015-2022) cliff retreat at Happisburgh (research question 1b), to illustrate the extent of geomorphological change that local residents are adapting to.

It begins by briefly outlining previous research on managed realignment from an environmental justice perspective (section 6.2) alongside relevant background context on coastal policy (i.e. Coastwise) for this chapter. The materials and methods section (6.3) outlines the subset of thesis data presented in this chapter, and the method adopted for calculating cliff rate of retreat at Happisburgh. Resident and policymaker perspectives and cliff retreat calculations are presented in the results section (6.4), which is structured according to different environmental justice harms. Section 6.5 discusses the main themes arising across the data, before a conclusion on the chapter's main findings (6.6).

6.2 Background context

6.2.1 Managed realignment and coastal adaptation: an environmental justice perspective

As outlined in the introduction to case study (2.4), the coast at Bacton and Walcott is currently defended until approximately 2040 by sandscaping, whereas at neighbouring Happisburgh, the coast is undefended and the SMP policy is currently managed realignment. Managed realignment is a policy option adopted in coastal areas that allows the shoreline to change, rather than defending its current position (AECOM, 2012). This can be facilitated through adaptation measures such as rollback, that moves infrastructure or whole settlements away from the coastline. For this reason it can be highly contentious for local communities and is commonly disputed (Tebboth, 2014; Nordstorm et al., 2015; Famuditi et al., 2018; Buser, 2020) (see section 2.4 for further case study background). Although relocation is presented as a transformative adaptation action to managing coastal risk in section 3.2.4 (O'Brien, 2017; Coastal Partnership East, 2019; Sayers et al., 2022; Huggel et al., 2022), academic research has also highlighted a risk of maladaptation from transformative responses, and a link between reactive adaptation, lower levels of resilience, and greater risk of maladaptation (section 3.2.3). The nature of the relationship between these concepts forms an important part of this thesis' conceptual framework, and are tested empirically with the results presented in this chapter, alongside the other empirical chapters.

As highlighted in the literature review (section 3.3.3), policy decisions to protect coastal areas at risk, or to not defend them, raise environmental justice issues (Cooper and McKenna, 2008). Longer-term impacts of at risk coastal areas which become undefended can include lower house prices, blight, demographic changes (such as rise in second home ownership) and uncertainty for the future (Nicholson-Cole and O'Riordan, 2009; Famuditi et al., 2018; Buser, 2020; Coastal Partnership East, 2019; Day, 2020; Brown et al., 2023). Extant research on the justice dimensions of managed realignment is predominantly in international contexts, focussed on risks to preserving cultural integrity for areas forced to retreat, particularly for vulnerable groups, and exploring how managed realignment can correct historical socio-economic injustices, such as land dispossession and discrimination (Siders and Ajibade, 2021; Maldonado et al., 2021; Perez and Tomaselli, 2021). There is increasing recognition that multiple dimensions of cultural heritage (from built infrastructure to social traditions and values, Vecco, 2010) are at risk through coastal change (Sesana et al., 2021).

As outlined in section 3.3.3, existing research on environmental justice issues in coastal management within a UK context has focussed on the social impacts of the change in coastal policy (SMPs) in 2005 away from indefinite coastal protection. Justice issues include the disproportionate financial and wellbeing impacts of coastal communities without coastal defences (distributional justice), and the extent to which communities were included in the process of the SMP policy change (participatory justice) (Milligan and O'Riordan, 2007; Nicholson-Cole and O'Riordan, 2009; Adger et al., 2011; Day et al., 2015; Famuditi et al., 2018). Research has also highlighted that vulnerability to flood risk in the UK can correlate with higher socio-economic vulnerability or deprivation (Walker and Burningham, 2011; Sayers et al., 2018). There is comparatively less research to date on the implications of environmental justice issues of managed realignment on community willingness to adapt to future coastal change.

In England, there is increasing policy attention on future adaptation plans of coastal settlements to be co-produced by local communities: it is described within the current FCERM strategy (EA, 2020) and is a key objective of CTAP, which provides funding to two local authorities in England (Norfolk and East Riding of Yorkshire) to trial options for coastal adaptation (Defra, 2022). This mirrors increasing attention and adoption of co-production in environmental governance worldwide (Turnhout et al., 2020). From an environmental justice perspective, community participation is argued to lead to more just outcomes, because local perspectives are incorporated into decision-making (Marion Suiseeya, 2020). Although previous research has cautioned the extent to which participatory coastal management in the UK has meaningfully incorporated local views (Few et al., 2007), other authors have highlighted the potential of coproduction within coastal adaptation policy to address the environmental justice issues associated with managed realignment (Tubridy et al., 2022).

Furthermore, although significant questions remain about the lack of funding and clearly defined roles on coastal adaptation (Brown et al., 2023), alongside the viability of reduced state and increased citizen responsibility in flood and coastal erosion risk management (McGinlay et al., 2021), a policy shift towards coproduction nonetheless represents an opportunity for stakeholders to input their views on adaptation to future coastal change. Empirical research that examines in-depth community perspectives of involvement in coastal decision-making, under a managed realignment context, is therefore timely to understand how to maximise community engagement in adaptation. To date, the co-production literature has focussed on issues of knowledge inclusion, particularly regarding indigenous groups or key stakeholders, (Muhl et al., 2023; Wamsler, 2017) or in urban environments (Wamsler, 2017), rather than coastal contexts.

6.2.2 Coastwise

This research coincided with the start of CTAP, which was launched in March 2022, after the survey took place (January 2022). This subsection briefly details what was known publicly about the scheme at the time of the research: a general overview of CTAP can be found in section 2.2.1. CTAP was announced by Defra in a press release in March 2022, and Members of Defra and the local council (NNDC) travelled to Happisburgh to formally announce the scheme (Defra, 2022). As detailed by interviewees, this was not a publicised event, however interviewees remarked seeing Rebecca Pow MP (Floods Minister and Parliamentary Under Secretary of State for Defra), alongside other policymakers at Happisburgh. Resident interviews were conducted in Autumn 2022, before the local project 'Coastwise' was formally announced (in summer 2023) (NNDC, 2023d), but at a time where there was local and national media reporting about the programme, alongside a letter to Happisburgh interviewees (residents) from the local MP Duncan Baker that referred to coastal issues and CTAP. Interviews with policymakers were conducted in Spring (2023), at which time a draft business case for CTAP was being prepared to the EA. At the time of writing (Spring 2024), Coastwise has begun stakeholder engagement in Bacton, Walcott and Happisburgh through public drop-in events at village halls ('Coastwise cafes', which ran in February 2024) (NNDC, 2023e).

6.3 Materials and Methods

6.3.1 Data collection

This section details the data selection and analysis steps for data presented in this chapter. General information on the sampling strategy for the geomorphological (section 4.3.1) survey (4.3.2) and interview (4.3.3) data collection, and a copy of the survey and interview questions can be found in the appendix (Appendices 1-4).

Interview and survey data

A total of 36 semi-structured interviews were completed; 22 of which were Bacton (n=15) and Walcott (7) residents, a further 8 were interviews with Happisburgh residents, and lastly, 6 interviews with local, regional and national policymakers. Due to the particular focus within this chapter on the coastal context in Happisburgh, survey findings from Happisburgh residents (n=23) are also presented here. Given the survey focussed on residents' views of coastal management in their own village, as opposed to neighbouring villages, survey responses from Bacton and Walcott are not included in this chapter. Interviews with local residents across the three villages and policymakers consisted of different questions but on similar themes. Themes discussed and reported on in this chapter include;

- Perceptions of a managed realignment coastal policy at Happisburgh (6.4.1)
- (For residents only) the lived experience of coastal change (6.4.2)
- Experiences of past community consultations on local coastal policy (6.4.3)

LiDAR data

To situate local resident and policymaker perspectives and experiences of environmental change at Happisburgh, secondary LiDAR data from the ACM Programme was analysed in ArcGIS Pro to calculate annual cliff retreat at Happisburgh between 2015-2022. Cliff retreat was calculated at Happisburgh only (rather than the entire case study area), given the focus on the coastal context at Happisburgh in this chapter, but also given that the villages of Bacton and Walcott are low lying (fronted by a continuous sea wall, and therefore not cliff frontages). The LiDAR data vary in date each year, but were all collected between October and January, giving a winter beach profile. The data have a minimum accuracy of +/- 0.10m RMSE (root mean square error). Similarly to Chapter 5, data were downloaded from the ACM programme's website (https://coastalmonitoring.org/cco/) as yearly digital elevation models, imported into ArcGIS Pro, and data cells were combined into a continuous raster dataset.

6.3.2 Data analysis

Interview and survey data

Section 4.4.3 outlines the approach to analysing qualitative data from the surveys and interviews. Interviews were thematically analysed using both an inductive and deductive coding approach, using the 3-step coding technique (i- initial, ii- focused, and iii- theoretical) advocated by Charmaz (2006), and developed from a grounded theory analysis approach by Glaser & Strauss (1967). Codes analysed in this chapter (Table 6.1) are a subset of the overall coding framework (appendix 6). Codes in this chapter specifically relate to different aspects of environmental justice (distributional justice, participatory justice and recognition, given these categories of harm are commonly used to analyse environmental justice issues (see Coolsaet, 2020)). As outlined further in section 3.3.1, these relate to the differential experiences societal groups face (distributional justice) (Kaswan, 2020), the ability of individuals to participate in decision-making (participatory justice) (Marion Suiseeya, 2020) and the extent to which individuals are accepted as a legitimate voice for environmental concerns (recognition) (Coolsaet and Néron, 2020). The three categories (hereafter themes) were applied, in the third step of qualitative coding, to organise codes of resident and policymaker perspectives according to environmental justice themes. Consequently, Table 6.1 and the results section is structured to firstly present views on managed realignment and the impacts of coastal change that relate to distributional justice (sections 6.4.1 and 6.4.2) followed by views on public consultations and coastal decision-making that relate to procedural justice and recognition (6.4.3). Whilst attention is given to the most common themes from the interviews and survey (explicitly stated in text), this is not at the exclusion of less common themes that nonetheless provide interesting insights into justice and/or this thesis' research questions.

Table 6.1. Themes (column 1) and codes[12] (column 2 and 3) on environmental justice arising from interviews with Bacton, Walcott and Happisburgh residents, and policymakers. As outlined in section 4.3.3, it was not possible to record (and therefore transcribe) two walking interviews with local residents (due to weather conditions), and therefore counts for Column 4 in Table 6.1 are out of 34 rather than 36. Light grey shading = expressed by residents only, dark grey shading = expressed by policymakers only, no shading = expressed by both interview groups (no. or % references by policymakers in relation to total references in brackets) (Table: I Cotton).

1. Theme	2. Parent codes	3. Child codes	4. No. interviews expressing code	5. No. references expressing code
Distributional justice	Distributional justice	Fairness in where gets protection	20 (4)	35 (29%)
		Impact of no defences	6	14
		SMP policy	5 (1)	9 (11%)
		Unjust decision-making	4 (1)	9 (11%)
		Impact of policies on risk	12 (1)	14 (7%)
		Poor implementation of policies	3	7
	Infrastructural intervention	n/a	23	48
	Capabilities	Witnessing coastal change	7 (1)	13 (8%)
		Worry for future of village and livelihoods	13	22
	Intergenerational justice	n/a	5 (2)	5 (40%)
	Relations of place	Cultural heritage and cultural value	11	28
		Sense of place	13 (2)	32 (6%)
	Inevitability	n/a	17 (2)	25 (8%)
	Scalar mismatches	Jurisdictional	17 (5)	62 (48%)
		Spatial	17 (2)	26 (8%)
		Temporal	20 (6)	31 (48%)
	Uncertainty	n/a	10 (5)	24 (67%)
Procedural justice and recognition	Procedural justice	Meaningful consultation	14	35
		Limits of consultation	14	21
		Everybody has a right to know	15	22
	Knowledge	Lack of knowledge	8	15
		Sources (who/what) of knowledge	16 (3)	29 (10%)
		Themes or subject of knowledge	14 (1)	26 (4%)

[12]References were counted for each separate point made by an interviewee, but purely repeated points under a particular child code were only counted once (to avoid double-counting).

	Trust	Motive of policymakers	15 (1)	35 (6%)
		Strained relations with policymakers	21 (1)	61 (5%)
		Good relationships with policymakers	9 (2)	12 (33%)
	Recognition	n/a	8	16
	Community relations	Sandscaping disagreements	15	23
		Car park disagreements	6	20
		General village tensions on future options	14	27
		Differences of opinion on coastal management	9	21
		Parish councils	10 (3)	12 (25%)
	CTAP	Language style	10 (1)	18 (6%)
		Perceptions on purpose	18 (6)	40 (38%)
	Adaptation	n/a	(6)	37

Use of key terms by interviewees

Local residents and policymakers commonly use the terms **'managed realignment'** and '**(managed) retreat**' interchangeably. While used synonymously, in theory 'managed realignment' refers solely to shoreline change, and therefore could refer to accretion and not just erosion. Furthermore, the term '**adaptation**' is typically used by interviewees to refer to an undefended coastal policy scenario (i.e. managed realignment), although adaptation could also take place on a defended coastline. In particular, policymaker interviewees use the terms 'adaptation' or '**transition**' to refer to specific actions that might fall under a managed realignment scenario, such as property rollback or relocation. This may be because 'managed realignment' or 'retreat' can be viewed unfavourably by local stakeholders (Nicholson-Cole and O'Riordan, 2009).

Coastal data

Two sampling areas were chosen to investigate rates of cliff retreat at Happisburgh, given the frontage contains two cliff areas of differing shape and erosion rates. A sampling area of 850m length was chosen at two sections to provide sufficient coverage of the overall frontage. In ArcGIS Pro, polygons of the sampling areas were created, and LiDAR data from 2015-2022 was extracted and clipped. The cliff line at each sampling area was identified using the slope function, and the top of the cliff line was traced for each year's LiDAR data. A line transect that represented a desired straight line of the cliff was created, to generate line transects every 5m along the frontage, at a 250m sampling length. This was used to calculate the distance between the youngest (2022) and oldest (2015) cliff lines. At Happisburgh South, gullying resulted in irregular erosion into and behind the general cliff line. To include this erosion in the rates of retreat, where it occurred the distance between the 2015 and 2022 cliff line transects was calculated solely using the areas of eroded land (as opposed to both eroded and intact areas), i.e. the distance across the gulleys was included, but not any intervening land. This provided an estimate of cliff retreat across an 8-year period, which was used to calculate an annual rate of cliff retreat, both for each transect and an overall average for each sampling area (Happisburgh North and Happisburgh South).

6.4 Results

6.4.1 Perceptions of managed realignment

Almost 20 years after a policy of managed realignment was introduced at Happisburgh, interview and survey data confirmed it is still disputed by Happisburgh residents, some of whom are vocal that Happisburgh should be defended. 78% of completed surveys from Happisburgh explicitly called for new or reinstated coastal defences in open-text answers. Meanwhile all Happisburgh interviewees highlighted the built cultural heritage or beauty of the village, with many listed buildings that are at risk from erosion. This highlights a sentiment of feeling let down by a national coastal policy formula that uses cost-benefit analysis, which only prioritises defences in areas of significant assets or population, rather than aspects of non-monetary value strongly felt by local residents. It also reveals the strong sense of place Happisburgh residents feel to their village:

> *"It's frustrating when you're basically told that, you're not worth it, you're not important. There's not enough show. A church founded in 9 something* (century) *or other isn't important. The lighthouse, the iconic things in all of North Norfolk, no…it's all going to go in the sea"* ~ Happisburgh resident

> *"I don't know how much it costs to reinstate some sort of sea defences that would prolong the life of the village, but compared with what is at loss, and what potentially could just go"* ~ Happisburgh resident

Even amongst Happisburgh residents who perceive management realignment in the long-term is inevitable nevertheless feel coastal defences are needed in the short-term, because the rate of coastal erosion is happening too quickly. The perceived risk is that the entire village of Happisburgh is under threat from erosion. This raises a critical question on how much time is required for adapting to managed realignment, potentially through relocation (the adaptation option described by interviewees below), and whether there is a role for coastal defences in the short-term to support a longer-term scenario of managed realignment.

> *"We need to buy some time, 30-40 years, so that the mechanism by which you move back an ancient village with old buildings, listed buildings, etc can be properly formulated. For the government and for the minister to come here and say 'adaptation is the only way forward and we, you, you're going to have to move', is facile in the extreme"* ~ Happisburgh resident

> *"More natural ideas just to slow things down, like planting things that can root in to hold the cliff in a bit more… not the rate it's going at the moment, it's just absolutely crazy, it's a whole village that we're going to lose…I know I'm going*

to lose my house, but to save the whole rest of the village would be nice" ~ Happisburgh resident

But not all Happisburgh residents think coastal defences should be used, or are practically feasible or attainable. A support for defences at Happisburgh is also less prominent amongst interviewees from Bacton and Walcott (currently protected from erosion and flood risk by the Bacton-Walcott sandscaping scheme) for economic reasons, but it was also reflected that views on managed realignment would be different if their own village were to face a similar scenario:

"We are not going to get defences. It will never happen. So there's no point in trying to kick people by saying, 'oh, we're going to continue campaigning for defences'…that causes more grief, for people already under pressure" ~ Happisburgh resident

"I think it should be left to go 'cause you know, there are all sorts of things for the birds to eat, the seed heads on the so-called weeds. And let's let it go. But, so there are different views" ~ Happisburgh resident

"When you think about those places like Happisburgh where they've just gone 'managed retreat ok, it'll just, your house will just fall into the sea'. And so sort of conceptually, and economically, you can say ok, well, that's the only option, but actually, when it's your home, and your children's future, you think no". ~ Bacton resident

Local policymaker interviewees highlighted that coastal defences are being used in Happisburgh currently (rock armour) to little effect, and that managed realignment would be required with or without coastal defences in place. Policymaker interviews confirmed CTAP funding would not be used on coastal defences:

"We've moved it (the rock armour) three times. You know, it's just not practical. There is absolutely no way you can stop erosion, whether defended or not". ~ Local policymaker interviewee

“CTAP isn't going to buy another 9,000 tons of rock, you know, that wouldn't be an appropriate sort of thing” ~ Local policymaker interviewee

Policymakers at all levels of government highlighted that the repeated use of defences for high-risk, fast eroding coasts needs to fundamentally change, referring to it as an unsustainable policy cycle that needs to be ‘broken’:

“You have to be careful that they give us some time for adaptation, and then when that time is out, they say, can you give us some more time? So that's the challenge” ~ Regional policymaker interviewee

“Getting a community to understand the need to adapt, getting them on board is at the moment very, very difficult. We have a cycle where we put defences in, and the community, they then lobby for further defences. ” ~ Regional policymaker interviewee

In summary, this section has explored the different perspectives of local residents and coastal policymakers on the use of coastal defences and a managed realignment policy at Happisburgh. Happisburgh residents raise distributional justice concerns in the differential protection allocated to different sections of the coast in England, and argue for more pluralistic decision-making in how coasts are valued for coastal defence schemes, going beyond economic assessments to also consider non-monetary forms of value, such as the cultural heritage of a settlement. Different ‘subjects’ of justice are referred to by interviewees, in terms of whether the issue of coastal defences and managed realignment at Happisburgh is spoken about at an individual, community or national (population) level. Further, interviewees raise different arguments for or against the use of defences at Happisburgh according to different spatial and temporal scales.

6.4.2 Lived experience of coastal change

Happisburgh residents spoke about the impact of living alongside an actively eroding coast, in both individual and community terms. At an individual level, residents highlighted the disproportionate impact of low house prices and difficulty selling or developing a local business, and the eventual cost to demolish their homes. At a community level, residents raised concerns about blight and a disappearing community:

> *"We treat people on the coast, like we would never treat anybody anywhere. No help when you lose everything you own. A bill for the demolition of your own property. You know, it's absolutely beyond the pale in the 21st century and the mother of democracies that you would treat people like that, but they do".* ~ Happisburgh resident

In particular, the lack of financial compensation for properties lost to erosion was seen as a significant injustice. A few residents, largely from Happisburgh but also from Bacton and Walcott, explicitly describe managed realignment as an unjust coastal policy if it is without financial compensation for properties that are lost to erosion. This has been a longstanding argument by local residents of Happisburgh, that if property was purchased pre-2005 (when coastal policy was 'hold the line' nationwide), central government cannot change coastal policy without compensation. Managed realignment without financial compensation and/or practical support is seen as both an abdication of responsibility by national government, and removing rights of citizens on the coast. One interviewee from Bacton raised an example of citizen compensation in other policy contexts, such as the (then) current development of the high speed railway HS2, implying unfair treatment of citizens at a national level.

> *"If you're going to compulsory purchase houses, knock them down because you're going to build a new railway…well, then those people are compensated*

> *at fair market value… You can't just suddenly change a policy, for the greater good, and then do nothing and try and get away with it on the cheap. That's just not right, and I mean Happisburgh is the most ridiculous example”* ~Bacton resident

> *“We have a bit of a legal case because it's kind of like going, ‘really I think you should house us should we become, you know, homeless, because your policy decisions have made us homeless, or changed from when we bought it’”* ~ Happisburgh resident

Local policymakers referred to the Coastal Erosion Assistance Grant (Defra, 2020), which provides local authorities with £6,000 to support the financial costs of demolishing at risk properties, but it was evident this is not on the scale of compensation envisioned by resident interviewees. Other financial support discussed by policymakers include a similar mechanism of planning rights that was offered in specific cases with the 2012 Happisburgh Pathfinder programme through the EN12 local planning policy (NNDC, 2024), or a national scale property reinsurance model for erosion or climate change (no such product currently exists in England asides from flood reinsurance (FloodRe), although a proposal for CoastRe has been circulated to Defra (EFRA Committee, 2019)). Regional and local policymakers highlighted the lack of centralised policy funding and guidance on adaptation to managed realignment is a key challenge at a local level. There is therefore still considerable uncertainty on financial mechanisms to support a policy of managed realignment, such as financial support discussed here specifically in relation to relocation of homes:

> *“Going back to Pathfinder, one of the things we did was when we got properties at risk. We actually worked with a reputable surveyor to actually give us a present day value so that in some cases, we might be able to give them that value so that they can move on, and they have a planning right to redevelop anywhere in North Norfolk”* ~ Local policymaker interviewee

“(On reinsurance) *We could look at that for coastal change or, you know, perhaps a wider climate change type reinsurance product, we could look at a levy funded type of model”* ~ Local policymaker interviewee

“Because of the funding, political and social issues, we can’t yet have a plan that definitively says we will help those people roll back and relocate because it’s not currently supported…we'd love to have a plan, but unless the plan is underpinned by appropriate funding and legislation, we can't really have the plan” ~ Regional policymaker

Happisburgh residents expressed mixed feelings towards the adaptation options trialled during the 2012 Pathfinder project. While interviewees were generally supportive of the programme in principle because it offered a form of financial support for at-risk properties, it was felt the financial support offered for demolished houses should have been higher. Furthermore, residents expressed disappointment in the price of the new houses built inland in the village through the programme, and the delays to completing construction works:

“They've had very expensive houses built just on the outside of here, near the school. And they're not houses for people that can afford to live here.” ~ Happisburgh interviewee

“And that went very badly in that three of them still haven't been built. The site itself isn't finished. There are people that have bought, and are living, but the road has never been finished in its tarmacking…and what they replaced them with, is ludicrously expensive, executive seaside homes with fancy kitchens, they didn't replace them with anything remotely affordable or accessible” ~ Happisburgh interviewee

Happisburgh residents (and Bacton and Walcott residents speaking about Happisburgh) articulated the disorientation they feel from the speed of loss of land at Happisburgh to coastal erosion. Processing loss of buildings and changes to one’s local surroundings was described as surreal:

“But then all of a sudden, you can't see those houses now…I can visualise the road in my head, but when I'm stood on the end of that road, you’re just like ‘Now, where is such and such’s house’. Because you’re trying to work it out. But it's just. It's been swallowed up like it's never existed”. ~ Happisburgh resident

“It’s got to mean, something to get your head around, the fact that when the coast disappears, I mean, it's not just sort of being knocked down, the whole landmass is gone isn’t it? The whole shape of the country has changed. So I was looking at the Ordnance survey map, the new one that had just come out, and for the first time ever I noticed they've actually sort of noted the bay that's forming on us” ~ Happisburgh resident

Cliff retreat (2015-2022)

The speed of environmental change at Happisburgh spoken about by interviewees is illustrated in Figure 6.1, which comprises of two graphs of 8-year cliff retreat across an 850m transect at Happisburgh North (panel a) and Happisburgh South (panel b), from 2015-2022. Below this are maps of Happisburgh North (panel c) and Happisburgh South (panel d) overlayed with the 2015 and 2022 clifftop line, to illustrate the extent of cliff retreat over the 8-year period. Cliff retreat is calculated as the distance (in metres, m) between the 2015 and 2022 clifftop line.

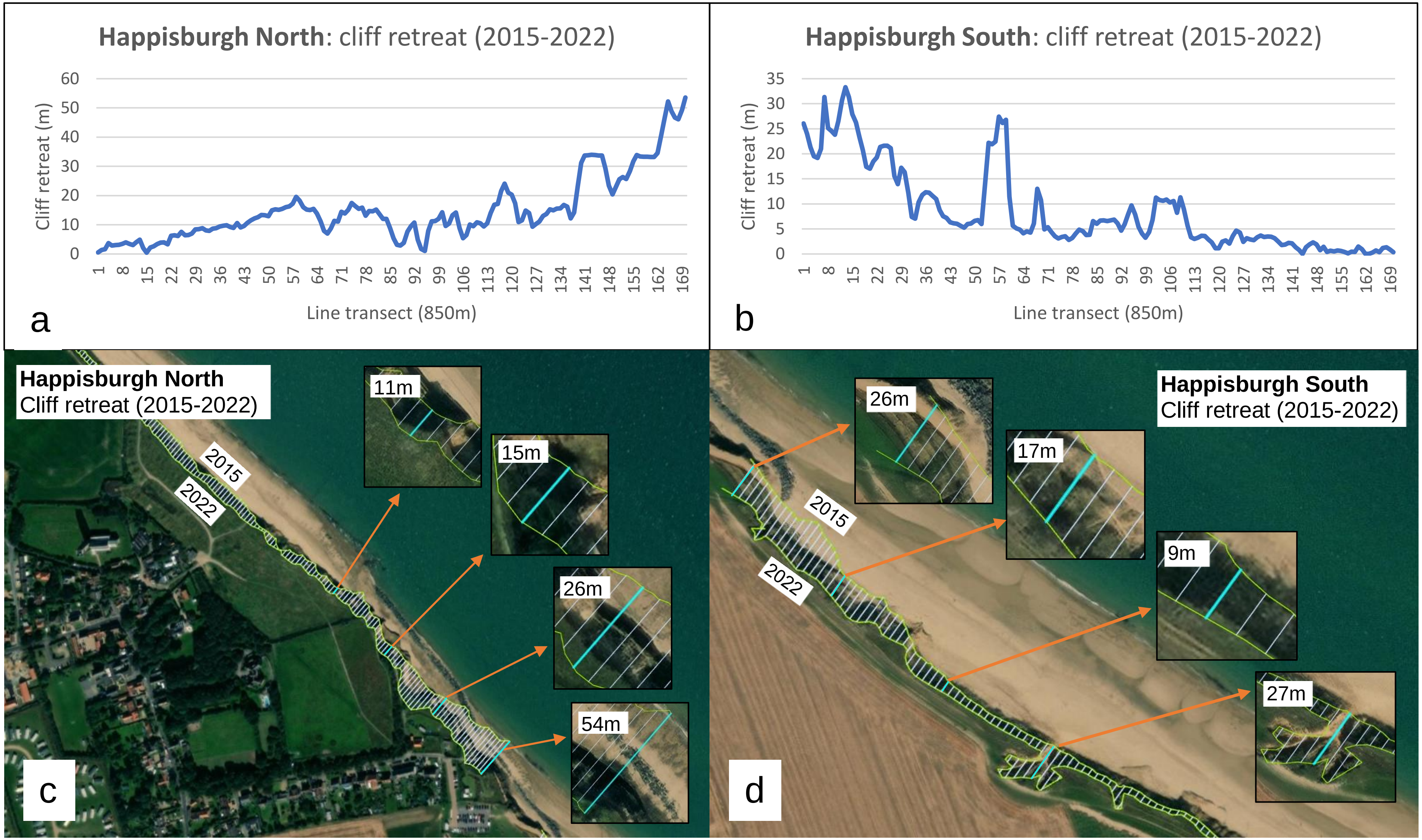


Figure 6.1 Cliff retreat (metres, m) at Happisburgh North (panel a, panel c) and Happisburgh South (panel b, panel d) from 2015-2022 (Data: Anglian Coastal Monitoring Programme). Satellite imagery from ArcGIS Pro © ESRI, 2023 (Figure: I Cotton).

As can be seen from Figure 6.1, both the North and South frontages have actively receded in recent years, but cliff erosion is highly variable. The extent of erosion at Happisburgh North varies from 0.4-53.6m, and 0.0-33.3m at Happisburgh South, over the 8-year period analysed. Despite being so close geographically, Happisburgh North and Happisburgh South show different patterns of erosion and different average erosion rates across the whole transect. Cliff retreat is not linear, and can occur after a period of stability, affected by a transition to different geological/geomorphological properties (e.g. grain size), and rainfall intensity (BGS, 2021), causing highly localised erosion patterns. Erosion rates were 15.0m (+/- 11.2m) on average across 2015-2022 at Happisburgh North compared to 8.6m (+/- 8.3m) at Happisburgh South. This corresponds to an average annual cliff retreat of 1.9m yr^{-1} (+/- 1.4m) at Happisburgh North and 1.1m yr^{-1} (+/- 1.0m) at Happisburgh South. These estimates are larger than long-term average annual estimates for Happisburgh of approximately 0.4m yr^{-1} (1907-1950) (Dickson et al., 2007) highlighting that erosion rates are currently greater than they were historically, and vary both naturally and due to anthropogenic intervention. For example, erosion rates at Happisburgh in 2001-2003 were 8-10m yr^{-1} (Poulton et al., 2006), following the demolition of hard defences (Payo et al., 2020).

Furthermore, cliff retreat estimates in Figure 6.1 reflect an average over an 850m cliff sampling area. Annual cliff retreat specifically at Beach Road (which is located at the end of Happisburgh North transect, and where many houses have historically been demolished) is notably higher. For example, panel c (bottom picture inset) highlights that 54m of cliff has retreated near Happisburgh car park from 2015-2022. This indicates that some sections of the cliff are particularly vulnerable, and having retreated several tens of metres inland, whereas elsewhere along the cliff there is less discernible change. At Happisburgh South, an embayment (area of fast eroding coast) can be seen towards the mid-way point of the transect (points 52-63 on the graph in panel b in Figure 6.1, corresponding to the bottom picture inset of 27m cliff change in panel d), suggesting a highly localised cause for erosion at this particular location. Given landslides and groundwater (water below the land surface) are notable contributors to erosion at the clifftop at Happisburgh (alongside erosion at the base of the cliffs due to waves) (BGS, 2021), the location of a historic channel refill could be one reason why the cliff is more easily eroded at this particular location. One Happisburgh interviewee articulated the impact of this localised and sporadic pattern of geomorphological change:

> *"Two years ago we were thinking 'oh that's getting close', but then nothing happened… we don't know where we are, it's, we're completely at the mercy of the tides and time"* ~ Happisburgh resident

Happisburgh interviewees reflected on the impact of witnessing this coastal change, which causes significant concern for some, and is a detriment to their mental health:

> *"I occasionally I have nightmares about trying to yell at people, 'You just need to leave the house now! It's about to fall!' So every now and then I have sort of like bad dreams about it, and then wake up going 'Oh no, it's fine. It's not happening tonight' "* ~ Happisburgh resident

> *"And I don't know whether I could bear to live here, looking at the church as I do, and obviously that goes first. That and the lighthouse kind of go at the same time, but I don't know whether I could bear the heartbreak of watching that building fall into the sea"* Happisburgh resident

> *"It's like the elephant in the room, it's there, but no one wants to talk about it, and people that are trying to sell their house and things like that don't want others talking about it"* ~ Happisburgh resident

Bacton and Walcott residents, commenting on Happisburgh, raise similar fears for their villages in the future if Bacton Gas Terminal is not further protected after sandscaping. A few interviewees who live on the coastal frontage recall the experience of their house shaking during storms, before sandscaping was introduced in 2019:

> *"We can see from villages up the coast what will happen. And it is a very, it's a slow death of, you know, a particular village and the particular community"* ~ Bacton resident

> *"We were relieved! about the sand* (sandscaping scheme), *that we might stand to be here a bit longer because of that. The house doesn't shake with the waves now, and the waves don't land on the front windows, like they used to"* ~ Walcott interviewee

The wellbeing impacts from erosion were also raised by policymakers, arguing that conversations on adaptation and the long-term plan for at-risk settlements are needed now to create a counteracting, positive vision of the future:

> *"The whole point of coastal transition and adaptation is that coastal change doesn't take you by any surprise, that it is managed and we want to see not only resilient communities, but we want to see thriving communities".* ~ National policymaker interviewee

In summary for section 6.4.2, Happisburgh residents raise many different impacts of coastal change (financial loss, blight, sense of loss, anxiety, and uncertainty for the future), that the village is disproportionately affected by through living alongside an undefended coast. Figure 6.1 highlights the fast rates of cliff retreat that the village has experienced in a recent 8 year period (2015-2022). This again highlights issues of distributional justice, in that certain settlements such as Happisburgh experience the impacts of coastal change more than areas which might be defended, such as Cromer (also on the Norfolk coast).

6.4.3 Community consultations and involvement in coastal management

Across all three villages, there is mixed opinion by residents on whether previous community consultations on coastal management have valued and incorporated local views. Views were particularly negative in Happisburgh, and interviewees felt their views were sought too late in the decision-making process, and thus not valued or listened to:

> *"'I would like residents to be consulted prior to any policy being formed…government would set out its policies to us. Open up a 12 week consultation. And then just go ahead with what they said anyway, because people were only ever open to any formal consultation after the policy had been set".* ~ Happisburgh resident

> (Referring to a previous consultation on offshore wind farm development) *"Parish council said no, District Council said no, central government went, 'you're having it. We've set aside as sort of a period of consultation, but the decisions already been made for it'."* ~ Happisburgh resident

This was a particularly strong theme from Happisburgh residents who completed the survey, where nearly a third commented on feeling ignored or overlooked, despite the open-text questions of the survey not specifically eliciting views on past community engagement:

> "*Constantly ignored by higher powers*" ~ Happisburgh survey respondent

> "*No one listens to the people of Happisburgh*" ~ Happisburgh survey respondent

In the case of Bacton and Walcott, there are both residents who are deeply satisfied and deeply dissatisfied with how the decision for sandscaping was made and publicly communicated, prior to its implementation in summer 2019. Residents who objected to sandscaping felt the decision had already been made to implement the scheme before community consultation. Because of this, some residents felt that local knowledge and lived experience of the area was overlooked and ignored. On the other hand, there are some Bacton residents who were satisfied with how local residents were involved and informed about the sandscaping scheme. As discussed in Chapter 5 (section 5.5.1) different resident perceptions on public consultation may link to an individual's overall trust in coastal management, perceptions of expert knowledge and views on sandscaping:

> *"What they could have done was bought in people who have been here, again, all their lives. And put them onto the steering committee and the decisions that were made. And just included them so that they could hear them out. But there wasn't the, locals weren't given anything like that. They were told 'this is what's happening, what do you think?' 'Well we don't like it'. 'Tough, it's going ahead'. That was the perception."* ~ Walcott resident

> *I think they have to involve, you know, local people, and not just go ahead, the powers that be to say 'this is what we're doing'. I think they'd do it anyway, but at least they should, you know, say, 'right guys, what do you think?' and hear what people have got to say. They'll do it anyway, probably, but I don't think they've done that, and that's what they should do going forward"* ~ Bacton resident

> *"I actually thought it was really good, how they, how the County Council actually organized it all…we had letters, we had flyers come through the post on a regular basis, there was a lot of interaction, and then it was, all the signs went up, and there was a picture of how it's going to work, and explaining how it works"* ~ Bacton resident

Consultation, and information about the coast, was framed by residents across the three villages as a citizen right (and lack of information as an injustice). All three villages spoke about the right to information on how their local coast is changing, as it affects livelihoods. Whether in the case of Bacton and Walcott on sandscaping, or of Happisburgh on managed realignment, a theme cross-cutting interviewees from different villages is a desire for more information and communication from coastal managers on coastal change:

> *"If there's going to be anything done which would inhibit my access to the sea, or anything which would have an impact on my enjoyment of it, I feel like I should be consulted because I bought there for that reason"* ~ Bacton resident

Policymakers expressed the aim to get as many residents as possible involved in Coastwise, which aims to develop community adaptation plans for high risk areas on the Norfolk coast (perceived roles and responsibilities of local residents in local coastal adaptation is explored in the following chapter (section 7.4.4), with this chapter focusing on perspectives of public consultation and community engagement on coastal change). Multiple engagement approaches were mentioned to achieve this, but the most common route highlighted by interviewees is through parish councils:

> *"Well, we will be employing a Community Liaison Officer. And obviously the first step is to introduce him or herself to parish councils. We've got to encourage parish councils to hold public meetings so we can explain what we're likely to be doing".* ~ Local policymaker interviewee
>
> *"So parish councils, I think are going to be absolutely critical. They provide that real grassroots connection to community. ".* ~ Regional policymaker interviewee

However, some resident interviewees expressed concern about parish councils acting as a community voice on coastal management issues for their village. Interviewees highlighted examples of differences of opinion between parish council members and other local residents on coastal management issues, such as the future location of Happisburgh car park, once access on Beach Road is lost due to erosion. Some local residents object to Parish Council proposals to create a new road, and thus alternative access route to the car park, at the back of Beach Road properties, and a few interviewees remarked they see no way in which differences of opinion can be solved:

> *"The entrance to the car park is, it's going to be threatened by the sea in a year or two. So we need to re-route. But it means putting a roadway down behind people's gardens, and now some of them are really up in arms against it. So whereas they'll tolerate the erosion or the erosion is some sort of theoretical thing, the idea of having a road down the back of their gardens, it just appals them and they're fighting it tooth and nail".* ~ Happisburgh resident

> *"I think you can't assume that the parish council speaks for everyone. Because there, always it's a small number of individuals and they, yeah. Not necessarily representative of everyone"* ~ Walcott resident

Meanwhile, policymaker interviewees expressed the challenge in how coastal management issues are covered by the media, in terms of sensationalising the issue of erosion and reporting inaccurate details on coastal policy. One local policymaker recounted an article in the Eastern Daily Press in January 2023 (which inaccurately claimed at-risk properties would be offered property compensation through the CTAP project):[13]

> *"That was kind of a classic one where they just wanted to write a nice headline, a big headline, and they did. And then it went in the EDP. And actually the BBC surprisingly copied it…that's not what it was about. And it then raises people's expectations and they'll come back to us 'well, what about this' like, well, we never said that, you know, we said lots of other good things, but we didn't say that"* ~ Local policymaker interviewee

[13] Eastern Daily Press, 2023. North Norfolk council set to buy homes at risk of erosion https://www.edp24.co.uk/news/23226258.north-norfolk-council-set-buy-homes-risk-erosion/

> *“We anthropomorphize the sea, you know, we instil this feeling of grief and some of that is the media. I understand, you know, places lost to the sea. The lighthouse lost its battle with the sea”.* ~ Regional policymaker interviewee

Resident interviewees who had heard of CTAP at the time of interviews remarked about the Press release by Defra, and communication from their local MP, as being vague and offering limited information of what CTAP would involve. This further highlights themes of distrust in policymakers that was discussed in Chapter 5:

> *“Our MP sent round a nice little letter, kind of ‘Oh! you know, I’ve been to Happisburgh. Heard you’re a bit concerned. Don't worry, there's Pathfinder 2’ sort of thing. And I'm going, what does that practically mean for anyone? And I couldn't find any practical anything in that document. There are a lot of woolly meaningless phrases and words”* ~ Happisburgh resident
>
> *“Well, the first thing I think we'd like is for them to talk to us about what it should achieve because including ‘transition’ in the title immediately raises concerns for people”.* ~ Walcott resident

In summary, there is scepticism amongst local residents, although not expressed by all, that past processes to seek community views on coastal management strategies have not meaningfully incorporated the views of local residents. This is a sentiment expressed most strongly by survey respondents and interviewees from Happisburgh, reflecting the different history of coastal management than at Bacton and Walcott. Overall, there is a widespread desire across all three villages for more knowledge and a greater say in how the coast is changing, and how it is managed. At the time of the research, local residents raise concerns on the extent and transparency of information about CTAP that is available, and the methods of community engagement that the project might use. This section has also highlighted once again, through the example of Happisburgh car park, the wide differences of opinion on practical aspects of managing coastal change at a local level, which raises key challenges for coastal managers on how differences of opinion can be accommodated.

6.5 Discussion

6.5.1 Environmental justice issues of managed realignment

The perspectives presented here highlight managed realignment at Happisburgh is still being disputed by local residents - almost 20 years on from the SMP policy change in 2005 – and may remain contested without a form of financial compensation and/or further short-term use of hard or soft engineering to slow the rate of coastal change. These findings correspond with past research on the SMP policy change at Happisburgh (Tebboth, 2014) and across Norfolk (Adger et al., 2011) that a lack of compensation for properties lost to erosion, or a lack of coastal defences, is perceived as removing rights and altering the 'social contract'[14] that existed between citizens and government pre-2006. Other studies elsewhere in the UK (Fairbourne, Wales) (Arnall and Hilson, 2023) and other countries (Gibbs, 2016; Lawrence et al., 2020; Hanna et al., 2020: 2021) similarly argue that managed realignment is being contested by communities at high risk, that the scientific basis of erosion projections or removal of defences are disputed, and that there are calls for property-level financial support. In this study, a frequently mentioned theme by Happisburgh interviewees is that the rate of coastal change experienced in recent years is too fast, ultimately threatening the cultural heritage of the village. It therefore appears that issues regarding managed realignment at

[14] The 'social contract' was theorised by philosopher Jean-Jacques Rousseau (1762) as a delicate balance in the relationship between individual and state in terms of the rights and responsibilities of each other.

Happisburgh have evolved over time from solely debates on continuing to defend (Adger et al., 2011; Tebboth, 2014) - to which opposing justice arguments can be made depending on different philosophical foundations of justice and different scales (Cooper and McKenna, 2008; Adger et al., 2011) - to how managed realignment in a just manner can be facilitated. Local Happisburgh residents put forward their perspective of an environmentally just approach as one that controls the rate of change at a pace that preserves the identity and integrity of the village, with adequate practical and financial support.

Existing research has argued acceptance of managed realignment takes considerable time and engagement with local communities (Moore, 2012; Sayers et al., 2022), perhaps even decades (Haasnoot et al., 2021), an imperative for initiating conversations now, to ensure adaptation is planned rather than reactive (Haasnoot et al., 2021), and less uncertain (Gibbs, 2016). This sentiment was reflected by many policymaker interviewees in this chapter, and Haasnoot et al., (ibid) report examples internationally of reactive retreat that create negative socio-economic impacts, such as not enough jobs where communities relocated. Of significance to research question 3, it can therefore be argued that proactive coastal adaptation is likely to be a more resilient and a more just approach to managing coastal change. However, a lack of funding and guidance on coastal adaptation entails there is still ambiguity on the practical dimensions to supporting communities to proactively adapt. The call for funding and national policy guidance for coastal adaptation by local and regional policymaker interviewees reflects longstanding arguments (O'Riordan et al., 2006; Day et al., 2015; EFRA Committee, 2019; Brown et al., 2023) that there is insufficient funding and guidance to practically support managed realignment at a local level for high risk coastlines such as Happisburgh. While the 2019 SMP refresh did lead to supplementary guidance documents (such as Natural Resources Wales, 2021), there is little detail on overcoming challenges to community engagement in coastal change issues, and studies in other national contexts reveal there is a similar lack of policy guidance worldwide (Lawrence et al., 2020, Hanna et al., 2020: 2021).

While the results reveal differences of opinion within and between local villages on the use of coastal defences, there is a clear distinction amongst those arguing for defences and the perspectives of coastal policymakers, who stressed no hard defences or market-value property compensation is possible under current Coastwise funding. This raises a relevant question, argued by Few et al., (2007) on whether participation in coastal adaptation can ever be fully participatory, if it is concerned with the *how* rather than fundamentally *if* managed realignment should be the SMP designation, and this reflects the position of some Happisburgh interviewees in this chapter. Although adaptation options under managed realignment, such as property and infrastructure rollback, have already been trialled at Happisburgh (2012 Pathfinder Programme), it may be challenging for local policymakers to present a compelling vision for local residents of managed realignment in the future, without further defences or property compensation. Furthermore, it may be difficult to sustain coastal adaptation planning at Happisburgh after the end of Coastwise funding, if an equivalent funding source for coastal adaptation is not financed at a national level. This could endanger community trust and limit progress towards effective, accepted and long-term community coastal adaptation planning.

6.5.2 Psychological dimensions of living alongside a retreating coast

Local residents across all three villages express concern about the future of Happisburgh and the impact of blight on the village. Furthermore, recounts of past experiences of coastal storms highlight the disproportionate financial and wellbeing impacts experienced by undefended communities in such events, when compared to other coastal settlements whose SMP policy remains 'hold the line'. The impact of coastal change for undefended communities in terms of blight and storm damage has long been highlighted (Adger et al., 2011; Brown et al., 2023). However, that Happisburgh interviewees also reported impacts at a community level from the 2012 Pathfinder programme, in terms of the affordability and delay to the construction of relocated housing in the village, highlights that adaptation options associated with managed realignment (in this case property rollback) need to also consider longer-term, secondary impacts to a settlement, and how potential solutions impact the characteristics and sense of place of a community.

A strong theme emerging from resident interviews are the wellbeing impacts of coastal change, and in particular, processing the rate of cliff loss from erosion. At 1.1m–1.9m yr^{-1} (+/- 1.0-1.4m), average annual retreat at Happisburgh North and South over a recent eight year period (2015-2022) is higher than historic annual average rates of cliff retreat (approximately 0.4m yr^{-1}, 1907-1950) (Dickson et al., 2007). Alongside the speed of cliff loss, cliff retreat calculations reveal erosion at Happisburgh is highly localised and variable year-to-year, and therefore unpredictable how much of the coast will retreat, and where. The inter-relationships between the social and natural components of the coastal system are evident from the empirical data presented in this chapter, and appear to relate prominently to uncertainty, which will be discussed further in Chapter 8. Disorientation associated with witnessing coastal change, where loss of one's local environment can render parts almost unrecognisable to before, is reported by Moore (2012) in their study of the 2012 Pathfinder programme in Dorset and East Devon.

Given that climate change is accelerating sea level rise and intensifying coastal storms across the UK (MCCIP, 2020), the psychological dimensions of coastal change may become increasingly significant as this century progresses. Residents from all three villages in this study express concern in how climate impacts may worsen coastal change, a sentiment echoed by residents at risk of flooding in Surrey, and erosion in Hemsby (also in Norfolk) (EA, 2021a). A recent account of a Hemsby resident who has lost their home to erosion (interviewed by the UK newspaper, The Guardian, 2023) reveals they did not have access to counselling at the time, and mental health support for flooding is also argued to be inadequate (EFRA Committee, 2019). Wider provision of mental health support for affected residents could therefore be beneficial, particularly given that concern of flood and erosion risk could act as a barrier to community engagement. While the EA (2021b) have quantified the mental health impacts of flooding, no such figure exists for erosion (although a project is underway) (EA, 2023b). Considering how coastal adaptation policies can simultaneously support the mental health impacts associated with coastal change therefore appears a relevant objective, and there may be relevant learning from research on eco-anxiety and climate anxiety (see for example Clayton (2020)).

6.5.3 Community involvement in coastal decision-making

There is widespread desire from local residents across all three villages for more information and communication from policymakers on managing coastal change. This is a theme that also strongly emerged from the empirical data explored in Chapter 5, and relates here to the timing of community consultations on coastal management. Happisburgh residents in particular argue their views were either not considered, or considered too late to have meaningful input into decision-making, when past coastal management proposals were shared for public consultation by the local council or the EA (the latter with respect to flood risk). Previous research on community involvement in SMP policy in East Anglia similarly concludes engagement was not fully participatory, or lacked sufficient and regular communication to communities (O'Riordan et al., 2006; Brennan, 2007; Adger et al., 2011). Issues of meaningful community consultation are not resigned to East Anglia or solely the SMP consultation process: other research on coastal management in Lincolnshire (Myatt et al., 2003), East Devon and Dorset (Moore, 2012), nationwide (Famuditi et al., 2018; EFRA Committee, 2019) and other locations (Costas et al., 2015; Domingues et al., 2017) all report community perceptions of being unable to fully contribute views in local decision-making. The significance of this, as evident in the perspectives of Happisburgh interviewees in this study, is there are high levels of residual scepticism in coastal decision-making, partly due to past experience. More positively, policymaker interviewees describe the role of communities in Coastwise as co-collaborating on transition plans about the future of local settlements. This suggests a higher and more collaborative approach to coastal governance, according to the different facets of coproduction outlined by Galende-Sánchez and Sorman (2021). Coastwise therefore has the opportunity to address past issues of participatory justice in coastal decision-making, with more equal power sharing of ideas on managing coastal change.

However, this research indicates there may be several challenges to community engagement in coastal adaptation discussions. The years-long dispute between Happisburgh Parish Council and local residents on rollback of the village car park exemplifies that a wide range of opinions will exist within a community specifically on *how* and *where to* with regards to relocating infrastructure. This has been found elsewhere, for example the rollback of a community café from the coast in Studland, Dorset, which took three years to reach consensus within the community (EFRA Committee, 2019). This has implications for how policymakers seek to engage local communities on coastal adaptation plans. While policymakers propose using multiple engagement routes as part of Coastwise, interviewees also highlighted the importance of parish councils in community engagement. The varying perspectives on managed realignment raised by different Happisburgh residents however, suggests that utilising one community group to express local views would be incomplete.

This study finds the views of Happisburgh residents coalesce around core just principles, such as financial support and community participation in coastal management, but diverge around the practical dimensions of adaptation planning (relocating infrastructure). A cluster of different positions, rather than one fixed 'community' view, is more apparent in the data. Wide-ranging engagement, using adept community facilitators, supported by time and resources, will be needed to ensure all voices are heard, as similarly argued by Moore (2012). Paradoxically, community engagement in coastal adaptation also needs to be mindful that not all residents may want to be involved in a topic as sensitive as coastal change, or involved to the extent envisaged by policymakers. Crucially, this requires high levels of trust from the outset between policymakers and local residents. Although later work in a Norfolk context has found relations between local authorities and communities have improved over time, and since the revised SMP publication (O'Riordan et al., 2014; Famuditi et al., 2018), that themes of tokenistic engagement are still expressed by interviewees here suggests building trust remains a key objective (as previously advocated by O'Riordan et al., 2006; Adger et al., 2011; Famuditi et al., 2018).

6.5.4 Communication channels and conflicting narratives

Resident interviewees recount previous public consultations, such as the 2005 SMP update and a previous Natural England proposal to allow flooding at Potter

Heigham (a nearby village on the Norfolk broads), were leaked by the local press before the consultation was officially announced by local authorities (CCAG, 2023b). Meanwhile, policymaker interviewees reflected on the challenge of sensationalised or inaccurate media reporting of coastal change, including local and national news articles in 2023 that falsely claimed property compensation would be offered as part of Coastwise. The role of the media in sensationalising and influencing narratives on climate or coastal change has been highlighted (Moore, 2012; Harcourt and Dessai, 2023), and policymaker interviewees argue it falsely raises public expectations of coastal policy that cannot be matched. This could potentially undermine public trust in coastal management, and at the time interviews with local residents were conducted in Autumn 2022, there was some scepticism of CTAP based on the limited information available since Defra's announcement in Spring 2022. It may therefore be practical to delay public announcements of future adaptation funding or policies, until more of a business case has been prepared by local government, so that the absence of information after a policy press release does not feed doubt and scepticism by local residents (for example, that local community views are being overlooked), or misreporting in local or national media.

However, these findings also relate to a more fundamental issue about how the future of a settlement, and the issue of coastal change, is framed in society. Recognitional injustices could arise where local residents feel the future of where they live, and its links to personal identity is misrepresented by media, local authorities, or the general public. One Happisburgh interviewee remarked there are tensions within the village on the extent to which Happisburgh is perceived to be defined by coastal erosion, and discussed, which is feared to impact housing sales. In Fairbourne, Wales, a village similarly at high risk of erosion and under managed realignment, local residents have spoken publicly against media labelling of being Britain’s first ‘climate refugees’ (Arnall and Hilson, 2023). Furthermore, the decision by Fairbourne residents to set up a rival community group (Fairbourne Facing Change) due to disagreements with the local council initiated group (Fairbourne Moving Forward) (Arnall and Hilson, 2023) reflects not just disagreements in practicalities of managing coastal risk, but a battle of narratives about a settlement and how it is changing, and a desire for communities to frame the narrative themselves. At Happisburgh the campaign ‘Save Happisburgh Action Group’ (2023) has recently been set up, and which continues longstanding community activism on coastal issues within the village. There may therefore be relevant learning in using an established, local authority and local resident community group for public announcements on local coastal issues. For example, local communities *provide rather than receive* information on coastal change to the media, and ultimately have greater ownership over the narrative of local coastal change.

6.6 Conclusions

This chapter has highlighted a range of perspectives and environmental justice considerations on managed realignment at Happisburgh, that may act as barriers to facilitating community engagement in conversations on future adaptation plans for the village. Managed realignment, and adaptation options associated with the policy, are unlikely to be accepted by local residents without sufficient financial and practical support to adapt (distributional justice). Furthermore, a call for coastal defences or soft engineering may continue if residents perceive the rate of environmental change as so fast that it threatens the identity and future existence of their village. Residual scepticism and distrust in past community consultations present obstacles in persuading communities to engage in Coastwise, and to trust it as a process that will meaningfully incorporate their views (participatory justice).

Differences of opinion within local communities on the practical details of rollback should not be underestimated in terms of the length of time and engagement required to reach a future adaptation plan that the village collectively has a sense of shared ownership in (recognition).

Overall, the findings highlight that a policy of managed realignment, and willingness to engage in coastal adaptation planning, is only likely to be accepted locally if it addresses the aforementioned justice issues of distribution, participation and recognition. If not, coastal adaptation planning may not be perceived by communities as a fair and legitimate process to manage coastal change. This chapter therefore demonstrates that incorporating justice principles into coastal adaptation planning is fundamental for successful community engagement, both to overcome historic environmental justice issues and to facilitate community willingness to adapt in future coastal decision-making. The next chapter of this thesis continues to explore community perspectives of managed realignment and long-term coastal change, but switching from the context at Happisburgh to that of Bacton and Walcott. Chapter 7 presents views of Bacton and Walcott residents on coastal management after sandscaping. It does so ultimately to explore whether, and on what scales, sandscaping has impacted social resilience to managing coastal change at Bacton and Walcott.

Chapter 7. Challenges to anticipatory coastal adaptation for transformative nature-based solutions: local resident and policymaker perspectives of a post-sandscaping frontage at Bacton and Walcott

*This chapter is based off the publication; Cotton, I., Forster, J., Lorenzoni, I. and Tolhurst, T.J., 2024. Challenges to anticipatory coastal adaptation for transformative nature-based solutions. Global Environmental Change, **88**, Article 102893. Available at: doi.org/10.1016/j.gloenvcha.2024.102893. IC's role in the paper: conceptualisation, methodology, data collection and analysis, writing (lead), review and editing*

7.1 Introduction

This chapter explores the perspectives of Bacton and Walcott residents and coastal policymakers on managing the risk of coastal change for the Bacton-Walcott frontage after the current sandscaping scheme. This principally relates to answering research question 2c, and draws upon the survey and interview data of Bacton and Walcott residents, and interviews with local, regional, and national policymakers. These perspectives are presented alongside sediment volume calculations, to explore changes at the Bacton to Walcott frontage in the first four years of sandscaping (research question 1a and 1c). A brief background section (7.2) summarises previous research on adaptation to future climate risk ('anticipatory adaptation'), with a particular focus on coastal contexts. Section 7.2 also outlines what has been said publicly to date by local government and other key stakeholders on coastal management post-sandscaping at Bacton and Walcott, and the future of Bacton Gas Terminal. Section 7.3 provides an overview of the data presented in this chapter, and the method used to calculate sediment volume estimates for the coast from 2015-2022. The results section presents resident and policymaker reflections on managing future coastal risk for Bacton Gas Terminal (7.4.1), perceptions of coastal adaptation under a future policy scenario of managed realignment (7.4.3) and perspectives on the role of local residents in coastal adaptation (7.4.4), alongside sediment volume calculations (7.4.2). The chapter ends with a discussion section (7.5) focusing on the implications of these perspectives on long-term social resilience to coastal change.

7.2 Background context

7.2.1 Anticipatory adaptation to coastal change, and perceptions of coastal risk

This sub-section briefly summarises notable research in the UK to date on public risk perceptions of climate change or coastal change, alongside perceived citizen responsibility of adaptation. Whilst it is strongly argued that communities need ample time to prepare for coastal adaptation (Day et al., 2015; Mott MacDonald, 2016; NNDC, 2016; EA, 2020), other authors have argued an overemphasis on time, and an overemphasis on the future, affects the way in which the public adapts to climate risks in the present (Nobert and Pelling, 2020). Studies on adaptation to extreme heat (Wolf et al., 2009; Porter et al., 2014; Nobert and Pelling, 2020) find households typically opt for reactive adaptive measures (e.g. clothing choices) rather than proactive or anticipatory measures with long lead-in times (e.g. retrofitting air conditioning). In a coastal context, international studies highlight coastal defences can undermine risk perceptions for vulnerable communities (Luis et al., 2015; Arias et al., 2017; Nunn et al., 2021) where over time experience of storms and strong attachment to the coast combine to increase risk normalisation (i.e. acceptance of coastal risk) (Luis et al., 2015; Domingues et al., 2017: 2021; Bertoldo et al., 2021). Crucially, Luis et al., (ibid) argue the role of risk perception in motivating coastal adaptation may be time-sensitive, and weaken if risk is perceived to be far into the future. A large number of factors have been found to contribute to risk perceptions or concern of climate change, and include perceptions of personal vulnerability (Sjöberg, 2000), the scale of the issue (Kollmuss and Agyeman, 2002), direct experience of flooding or extreme weather (Spence et al., 2012; Capstick et al., 2015; Demski et al., 2016; Arias et al., 2017; Bruine de Bruin and Dugan, 2022), political values (Whitmarsh, 2008; Ogunbode et al., 2017) and age (Grothmann and Reusswig, 2006; Whitmarsh, 2008; Zaalberg et al., 2009).

Previous research on coastal adaptation has focused on property-level flood adaptation measures rather than erosion risk, or is typically from the perspective of key stakeholders rather than local residents (Esteves and Thomas, 2014; Van der Plank et al., 2020; Brown et al., 2023). Furthermore, nature-based solutions (the use of natural features and processes rather than man-made infrastructure (Seddon et al., 2020)) are increasingly framed as an alternative to the maladaptive, repeated use of hard defences in coastal management (Nunn et al., 2021). While the role of nature-based solutions in buying time and providing a stepping stone from ‘hold the line’ to ‘managed realignment’ has been acknowledged (Brown et al., 2023), there is little research directly evaluating this and the practical dimensions of the policy transition (Brown et al., 2023), alongside a lack of case study research at a local level on adaptation to coastal change (Harcourt et al., 2023; Magnan et al., 2023). Anticipatory adaptation in contexts where nature-based solutions are introduced has been understudied, with previous research on nature-based solutions instead exploring public perceptions on their effectiveness (Gray et al., 2017; Joseph and Humphries, 2018; Anderson and Renaud, 2021), uptake (Moraes et al., 2022) or underlying policymaker or stakeholder motivations for their introduction (Santoro et al., 2019; Ferreira et al., 2022).

As outlined in section 2.2.2, local authorities and risk management authorities have a responsibility to manage erosion and flood risk, respectively, but roles and responsibilities for adaptation is more ambiguous in the current FCERM policy (EA, 2020). Work by Van der Plank et al., (2022, p.14) argues responsibility for adapting to coastal flood risk can be broken down into five typologies: "*personal responsibility to be aware and prepared…financial responsibility to bear the costs…citizen responsibility to be engaged in decision-making…legal responsibility to act within the scope of the law…and state responsibility to the welfare of its citizens*". Therefore, the authors (ibid) argue responsibility for adaptation cuts across different actors, and includes the state but also at an individual level. Van der Plank et al., (2020) investigated perceived public responsibility for flood risk management in the North West (Lancashire and Cumbria) and South (Hampshire, Dorset, Isle of Wight) of England, from the viewpoint of local authorities and stakeholders. Interviews revealed a wide range of opinions on the role of communities, from solely being aware of flood risk, to being equally responsible in writing local flood risk management plans (Van der plank et al., ibid). There is increasing emphasis in FCERM policy (EA, 2020) on local community involvement in coastal adaptation plans, and a key objective of CTAP, as similarly discussed in Chapter 6 in the context of Happisburgh, is for local authorities to co-develop transition plans with local communities in high risk areas. While there has been ample research on public participation in SMPs (for example Few et al., 2007; Nursey-Bray et al., 2017), as similarly highlighted in Chapter 6, research is now needed to understand local resident perspectives on co-developing coastal adaptation plans, and how to facilitate a willingness to adapt proactively to coastal change amongst affected communities.

7.2.2 The future of the Bacton-Walcott frontage

This sub-section outlines public announcements relating to the future of the sandscaping scheme and Bacton Gas Terminal, as it is pertinent to findings discussed in this chapter. General background context on the sandscaping scheme and coastal management at Bacton and Walcott can be found in section 2.4. There has been no public communication by either NNDC or the Bacton Gas Terminal operators that the sandscaping scheme will be repeated. There has, however, been frequent media coverage speculating that Bacton Gas Terminal will repurpose into a Bacton Energy Hub in the future and supply renewable energy (for example EDP, 2023b). In December 2022, the Bacton Energy Hub Special Interest Groups (2022) produced a report outlining the business case for renewable energy development at the site (hydrogen, offshore wind, and Carbon Capture and Storage (CCS)). Soon after the Government's announcement in summer 2023 of continued annual gas and oil licenses in the North Sea (HM Government, 2023b), Bacton Gas Terminal was officially granted a license for CCS from the North Sea Transition Authority (NSTA) in September 2023, the first time such permits were authorised (NSTA, 2023). During a visit to Bacton Gas Terminal in Autumn 2023, then Prime Minister Rishi Sunak described it as a "*hidden hero*" for UK domestic energy production (BBC, 2023c, p.1), signalling strong political interest at a national level in continuing to protect the gas site from the risk of coastal change, and the role it could play to meet the UK's 2050 Net Zero target.

NNDC's website for Coastwise (a £36M project in North Norfolk funded by Defra to trial different initiatives for coastal adaptation, see section 2.2.1) includes information about "*the plan for the Bacton to Walcott coastline once the sandscaping has depleted*" (NNDC, 2023d, p.1). It states there is a possibility "*further coastal work*" (NNDC, ibid, p.1) may take place by Bacton Gas Terminal, but it does not specifically refer to a repeat of sandscaping, nor that any future work would protect the villages of Bacton and Walcott again. Instead, it stresses that the frontage should prepare to adapt to coastal change (under managed realignment): *"The project* (sandscaping) *looks to provide up to 15 years of protection for the Bacton Gas Terminal, creating time to plan and prepare for coastal change in this area. The terminal may complete further coastal work to protect the site in the future. This may benefit the Bacton to Walcott coastline, but this is not certain. We will need to work with the communities to plan for future coastal change, and Coastwise allows us to begin this planning process" (NNDC, ibid, p.1).*

7.3 Materials and Methods

7.3.1 Data collection

Social data

This chapter draws upon the survey responses (77) and interviews (22) of Bacton and Walcott residents, and compares these perspectives with the views of local, national and regional policymakers (6) working within a coastal flooding or erosion context. All of the policymakers interviewed were familiar with the sandscaping scheme and SMP policy context at Bacton and Walcott. As noted in Chapter 6 (section 6.2.2), CTAP was officially announced by Defra in spring 2022, subsequent to the survey (January 2022) but before resident (Autumn 2022) and policymaker interviews (Early 2023). Although CTAP had been officially announced at the time of the interviews, there was no official communication on where within Norfolk projects would take place, and NNDC had not announced information about the local project, subsequently named Coastwise. Chapter 4 details the sampling strategy for the survey (section 4.3.2) and interview (4.3.3) data collection, and a copy of the survey and interview questions can be found in the appendix (appendices 1,2, and 4). Section 4.3.2 details the survey response rate and response count by village, while section 4.3.3 details counts of in-person, phone or online interviews. Themes and topics reported on in this chapter include:

- Local resident and policymaker perspectives on the future of Bacton Gas Terminal, and the risk of coastal change during and after the sandscaping scheme;
- Policymaker perspectives on community involvement in Coastwise, and a policy of managed realignment;
- Resident perspectives on perceived responsibility in participating in coastal adaptation decision-making.

Coastal data

This chapter analyses the same LiDAR dataset from the ACM Programme as investigated in Chapter 6, which is annual LiDAR (elevation) estimates from Bacton Gas Terminal to Happisburgh, from 2015 – 2022. Further information on the dataset can be found in section 4.3.1.

7.3.2 Data analysis

Social data

Closed-text survey questions were analysed using descriptive statistics, and open-text survey questions and interview data were thematically analysed using an inductive and deductive coding approach that is detailed in Chapter 4 (4.4.2 and 4.4.3). Table 7.1 in section 7.4 details the codes and themes of the interview data explored in this chapter. The full coding framework can be found in Appendix 6.

Coastal data

This analysis sought to compare changes in sediment volume from Bacton Gas Terminal to Happisburgh in the four years prior to sandscaping (2015-2018, inclusive) with the four years after sandscaping (2019-2022, inclusive). Five sampling areas of 850m length were chosen at Bacton Gas Terminal, Bacton, Walcott, Happisburgh North and Happisburgh South (see sampling areas in Figure 7.1 below). An 850m sampling length was used, given it covers the majority of the frontage at Bacton Gas Terminal and the three villages. As reported in Chapter 6, given the coastline at Happisburgh contains two cliff areas of differing shape and erosion rates, two sampling areas were chosen for Happisburgh (Happisburgh North and Happisburgh South) to account for these differences. The Happisburgh sampling areas (4 and 5 in Figure 7.1) are the same as in Chapter 6.

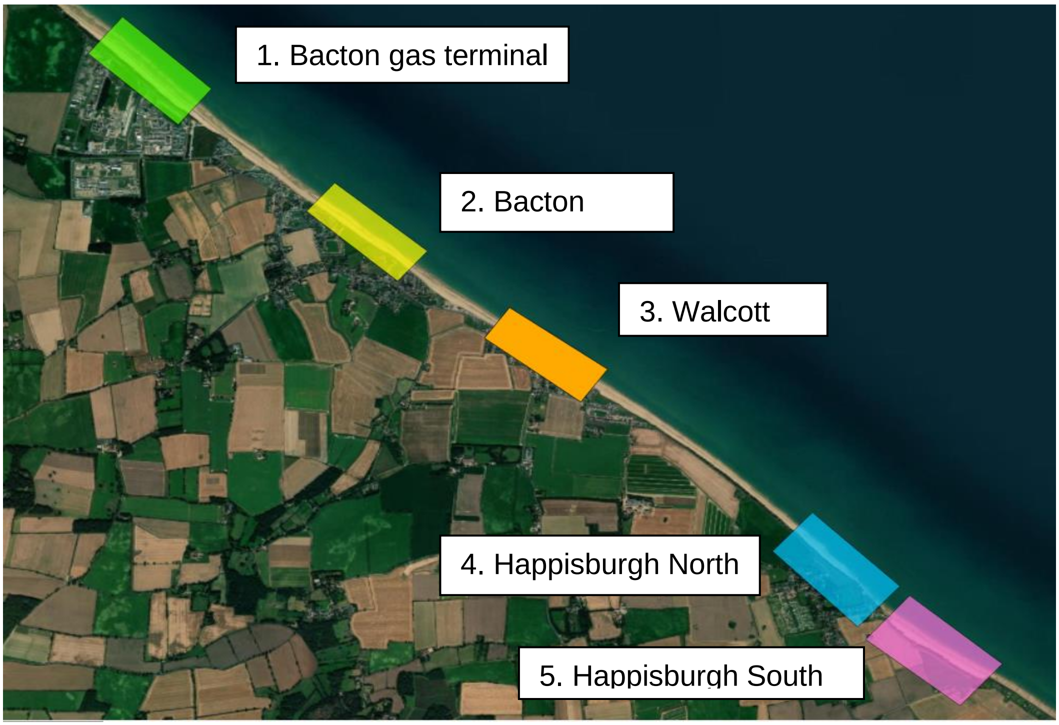


Figure 7.1 Sampling locations for sediment volume calculations (from top to bottom): 1) Bacton Gas Terminal (green) 2) Bacton (yellow) 3) Walcott (orange) 4) Happisburgh North (Blue) and 5) Happisburgh South (Pink). Sampling locations were all a fixed 850m in length, and contained the maximum LiDAR data width across the years 2015-2022 (Figure: I Cotton).

In ArcGIS Pro, polygons of the five sampling areas were created, and LiDAR data from 2015-2022 was extracted and clipped. The cliff line or sea wall at each sampling area was identified using the slope function. Where the sampling area contained a cliff (for example at Bacton Gas Terminal, Happisburgh North and Happisburgh South), the top of the cliff line was traced for each year's LiDAR data (2015-2022). Conversely, where the sampling area contained a fixed sea wall (at Bacton and Walcott), the sea wall line was used for all LiDAR years, given the position of the sea wall is fixed. Therefore, beach volume calculations included all sediment at each sampling area to a depth of approximately -2m (which equates to the maximum LiDAR width in the ACM programme data), and to the top of the cliff or sea wall. The LiDAR data was clipped a second time, to remove any elevation data inland of the cliff/sea wall in each sampling area. Surface volume was calculated for each sampling area from 2015-2022.

7.4 Results

Table 7.1 summarises the codes and themes emerging from the interview data reported on in this chapter. The results section is ordered according to these three themes, and first presents views of sandscaping and Bacton Gas Terminal (section 7.4.1, which corresponds to codes under the first theme 'coastal management') followed by views on managed realignment in general and maladaptation (section 7.4.3, which corresponds to codes under the themes 'scale' and 'adaptation'), and lastly perspectives of community responsibility in coastal adaptation (7.4.4, codes under the theme 'coastal management' and 'adaptation'). The table reflects counts of Bacton and Walcott residents only (i.e. tallies have removed references from Happisburgh residents for this chapter). The table is shaded in grey-scale to illustrate themes discussed solely by residents (light grey shading) and policymakers (dark grey shading). Themes expressed by both interview groups are not shaded, and the number/percentage split of references from policymakers is noted in brackets.

Table 7.1 Themes (column 1) and codes[15] (columns 2 and 3) arising from interviews with Bacton and Walcott residents, and policymakers. Some parent codes (column 2) are divided further into relevant child codes (column 3) (parent codes without child codes are listed as 'n/a' (not applicable) in column 3). As outlined in section 4.3.3, it was not possible to record (and therefore transcribe) one Happisburgh resident and one Bacton resident walking interview due to weather conditions, and so coding totals reported in this chapter do not include the walking interview from Bacton (i.e. counts for Column 4 in Table 7.1 are out of 21 rather than 22) (Happisburgh interviews are not reported on in this chapter). In columns 4 and 5, codes with light grey shading = expressed by residents only, codes with dark grey shading = expressed by policymakers only, codes with no shading = expressed by both interview groups (the number or % references by policymakers are in brackets). Codes are arranged within each theme group (column 1) according to most common codes (see number of interviews that expressed a particular code, column 4) (Table: I Cotton).

1. Themes	2. Parent Codes	3. Child Codes	4. No. interviews expressing code	No. references expressing code
Coastal management	Bacton Gas Terminal	n/a	17 (4)	34 (29%)
	Feeling secure	n/a	17	47
	Perceived responsibility	Policymaker responsibility	13	26
		Community responsibility	(2)	2 (100%)
Scale	Scalar mismatches	Temporal	18 (6)	29 (52%)
		Spatial	13 (2)	19 (11%)
		Jurisdictional	13 (5)	43 (70%)
	Environment/ social tensions	Climate change	11 (3)	21 (24%)
		Need to consider environment	8	16
	Uncertainty	n/a	8 (5)	22 (73%)
Adaptation	Infrastructural intervention	n/a	19	37
	Coastal Transition Accelerator Programme (CTAP)	Perceptions on purpose	13 (6)	24 (63%)
	Adaptation	n/a	(6)	37 (100%)

[15] References were counted for each separate point made by an interviewee, but purely repeated points under a particular child code were only counted once (to avoid double-counting).

7.4.1 Feeling secure and the future of Bacton Gas Terminal

Over three-quarters of the Bacton and Walcott residents interviewed expressed a sense of security from the risk of coastal erosion or coastal flooding by living adjacent to Bacton Gas Terminal. The terminal was described as an infrastructure that will be protected at any cost. Although the villages were vulnerable to flooding and erosion before sandscaping, some residents who had previous direct experience of storms commented that the introduction of sandscaping has assuaged any previous concerns about property damage.

> *"I said 'Look. Look out of our window, you've got two aerials there, and you've got Bacton gas site. They are not going to let that drop into the sea, because it supplies a third of the country's gas'. So, as long as that is there, this little house will be fine"* ~ Bacton resident

> "*I think that we're very lucky 'cause we're one of the sort of safest places on the North coast for erosion because, we have got the gas site and they will never let it fall into the sea*" ~ Bacton resident

> *"Our house had been trashed, and we had to move out for 15 months…We weren't overconcerned, unless we heard that the wind the tides and what have you were going to get that surge again… while that sandscaping's there, I don't believe it will. I believe we are perfectly safe"* Bacton resident

Contributing to this perceived sense of security is the observation that the implementation of sandscaping- at a cost of £21M (Johnson et al., 2020b)- occurred at a time where elsewhere along the Norfolk coast there has been no further intervention of defences, despite high erosion risk:

> *"I should imagine that Happisburgh, Hemsby, Scratby and that area, they'll be the areas that will be in need of moving, because already properties have fallen into the sea, so again, it may not look the prettiest thing, but the gas works in*

Bacton are really significant to Walcott, because they've got to protect that in the short term" ~ Walcott resident

"Bacton feels like a really secure location because so much has been committed to ensuring we stay buffered…when everything else is so uncertain at the moment, I mean the fact that we can be fairly sure that we won't fall into the sea like Happisburgh residents" ~ Bacton resident

Furthermore, residents reflected that Bacton Gas Terminal will only increase in importance in the coming decades: socioeconomic and geopolitical issues at the time of the interviews (Autumn 2022), such as the cost of living crisis and war in Ukraine, were both mentioned by resident interviewees as evidence that the terminal is of great importance to the UK's energy security. While several residents debated whether this would change through the pursuit of green energy policies, it was more commonly thought that the terminal will repurpose as a hydrogen and CCS site in the future, and therefore remain a critical energy infrastructure for the UK in the decades ahead.

"I did read an article. I need to reread it, which I think said something about using the gas field, the empty gas field, for carbon capture? …Yeah, so they'd have to maintain that, I suppose, wouldn't they? ~ Bacton resident

"The money that the North Sea is going to generate, to put that sand there again by the Dutch, it's peanuts…they earn so much money out of those gas licences now, 'cause we're not going to buy a Russian gas again. Nor is Europe" ~ Walcott resident

There is evidence that the sandscaping scheme has impacted the property market, with a few new residents confirming they would not have moved to the area without the scheme:

"*I hadn't really considered the coast because of coastal erosion…and then when we came here and we saw the sandscaping, and I think it sort of gave* *that, sort of, dream that I could live by the sea, that it would be safe for a while*" ~ Bacton resident

"I thought 'sod it, I'm going to go for it' 'cause it's going to be safe now for Bacton Gas Station, the terminal. And so they're going to protect that" ~ Walcott resident

Drawing on the observations above, there is a widespread hope amongst residents that sandscaping, or some form of coastal protection, will continue beyond the current project. 51% of survey respondents (n=68) called for sandscaping to be repeated after the current scheme's projected lifetime[16], and a further 28% of respondents called for more hard defences or some form of alternative sea defences. In interviews, while some residents expressed a hope for further intervention, for others this was more strongly felt as an expectation that the coastline at Bacton and Walcott will remain defended:

"I would hope for that by the time that this needs to be done again, I'm hoping that Bacton Gas Terminal is still important enough that needs to happen again" ~ Bacton resident

"That's a lot of money's worth there. They're not going to let that be undermined by the sea. They're going to save that" ~ Walcott resident

"Bacton gas site, it supplies a third of the country's gas, well, if that isn't in the national interest, I don't know what is…it's a national thing like the Channel Tunnel. And it needs to be looked after appropriately, and that needs national funding" ~ Bacton resident

Despite this belief, there is not currently, nor has there ever been, any public communication indicating that sandscaping will be repeated. Interviews with

[16] In response to survey question; "*What coastal management, if any, do you think should happen in your village in 15-20 years, which is after the projected lifetime of the Sandscaping scheme?*" (total responses to question= 68)

policymakers confirmed this is merely speculation at present. There is a lot of uncertainty, currently, about the future of the terminal, the future decision-making of terminal operators, and its implications for the coastal management policy of the frontage.

> *"There are going to be those discussions sort of with, I imagine with government, with planners, about those possibilities and those companies. And then if it is re-used like that, it's like well within that mix needs to be the 'well, OK, how's the site going to be managed? Is it going to roll back from the coast or is there the potential for future, for the sandscaping, or other activities like that?' So, but I wouldn't want to say that would be the case because it's a complete unknown"* ~ Local policymaker

> *"I think, so that is the big question as to whether they* (the terminal operators) *have future, you know, aspirations to repeat a similar sandscaping exercise in 15 years' time"* ~ Regional policymaker

> *"The sandscaping project has certainly been successful in terms of buying time to have conversations, particularly with the community in that area, around long-term adaptation and that need to live with rising tides. And that's not to say that a future way of improving resilience wouldn't be another sandscaping. So I think it's too early to say"* ~ National policymaker

In summary, the implementation of sandscaping appears to have contributed to confidence within the local community that the Bacton and Walcott frontage will remain defended. This confidence has led to anecdotal evidence of increased buying and selling of local property, and reflects a hope or expectation for many residents that sandscaping will be repeated at the end of its lifetime. There is evidence that this perceived sense of security is becoming more strongly felt by local residents since sandscaping was completed in 2019, due to emerging socioeconomic and geopolitical contexts that further underline the importance of Bacton Gas Terminal. However, a second sandscaping scheme is currently purely speculation, and there has been no official communication, by local government or the terminal operators, that the current project would be repeated.

7.4.2 Sediment volume change Bacton to Happisburgh, 2015-2022

One policymaker reflected that any decision on whether to repeat sandscaping would be taken further into the scheme's lifetime, once it has become clear how the scheme is performing geomorphologically:

> *"You know, if it performs as we hope it will do, you know they* (Bacton Gas Terminal operators) *will get to a point where they'll need to start thinking about it, but that won't be at the end of the scheme, say 15 or 20 years. I personally would expect them to be looking at it probably 10 years if it's performing as we hope it is"* ~ Local policymaker

This section analyses sediment volume change in the first four years of the scheme. Figure 7.2 and Table 7.2 detail changes to beach sediment volume at Bacton Gas Terminal and the three villages before sandscaping (2015-2018) and after sandscaping (2019-2022). Volume estimates in Table 7.2 encompass all sediment present from the top of the cliffs (at Happisburgh) or sea wall (at Bacton and Walcott) to the entire beach area, including the intertidal zone (to approximately -2m elevation). Percentage change in sediment volume compared to the previous year is also calculated and listed next to sediment volume estimates (in red or green font in Table 7.2, to indicate percentage decrease or increase, respectively).

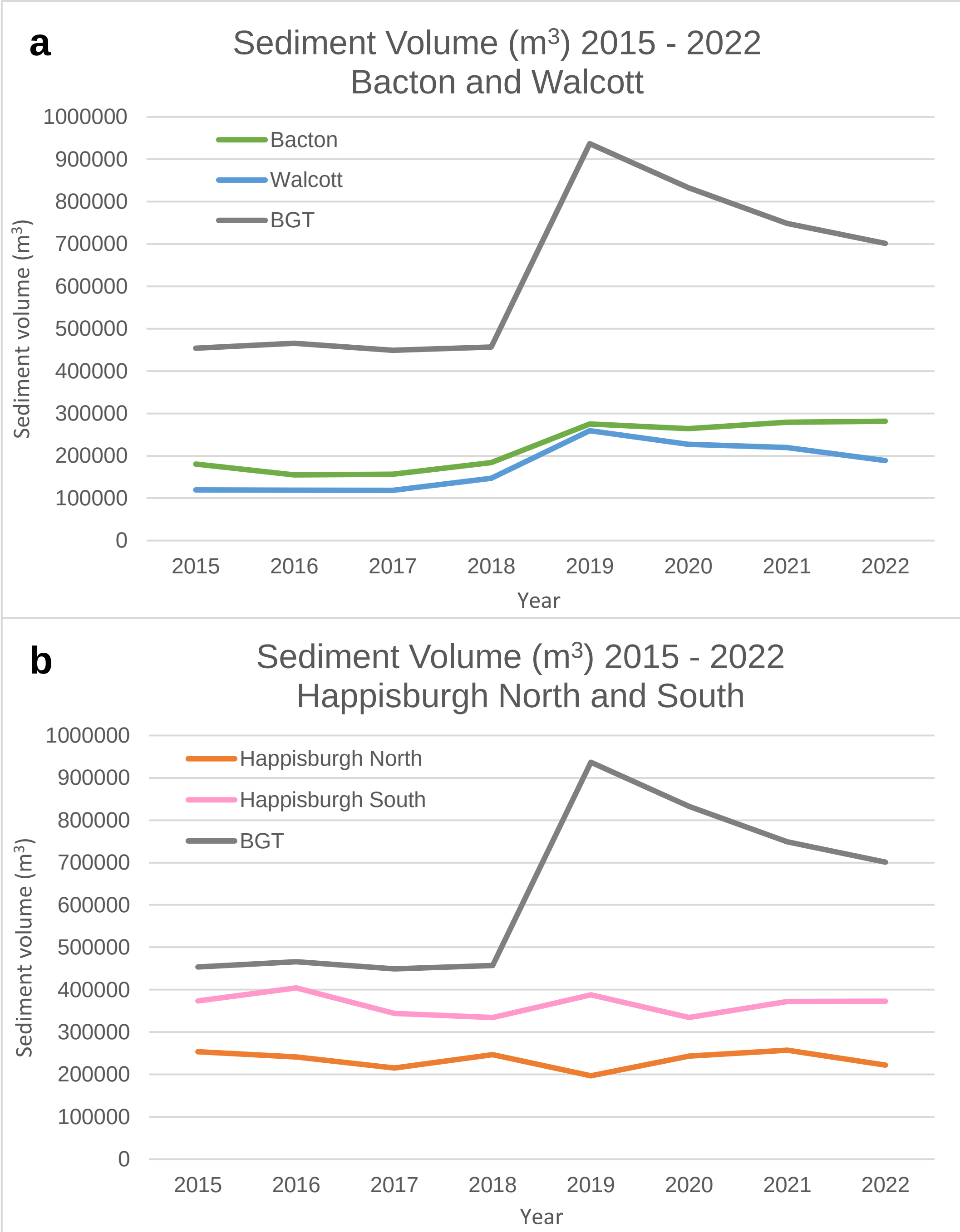


Figure 7.2 Surface volume estimates (gross, m^3) year to year (2015-2022) at Bacton and Walcott (panel a) and Happisburgh (panel b), with respect to Bacton Gas Terminal (BGT, grey line in panel a and b, where the majority of sediment was placed from sandscaping in 2019) (Figure: I Cotton).

Table 7.2 Surface volume estimates (gross, m^3) and percentage change (% against previous year) at Bacton Gas Terminal, Bacton, Walcott, Happisburgh North and Happisburgh South from 2015-2022 (Table: I Cotton).

Surface volume (m^3), and percentage change (%) from previous year					
Year	**Bacton Gas Terminal**	**Bacton**	**Walcott**	**Happisburgh North**	**Happisburgh South**
2015	453,879	180,424	119,436	253,669	373,726
2016	465,606 (+3%)	154,949 (-14%)	118,735 (-1%)	241,437 (-5%)	404,196 (+8%)
2017	449,106 (-4%)	156,393 (+1%)	118,427 (-0.3%)	215,417 (-11%)	343,845 (-15%)
2018	456,980 (+2%)	183,725 (+17%)	146,903 (+24%)	246,317 (+14%)	334,239 (-3%)
Sandscaping – Summer 2019					
2019	936,830 (+105%)	274,999 (+50%)	259,298 (+77%)	196,676 (-20%)	387,996 (+16%)
2020	832,796 (-11%)	264,420 (-4%)	227,371 (-12%)	242,984 (+24%)	334,633 (-14%)
2021	749,019 (-10%)	279,071 (+6%)	219,259 (-4%)	257,119 (+6%)	372,069 (+11%)
2022	701,276 (-6%)	281,639 (-0.9%)	188,577 (-14%)	221,865 (-14%)	372,900 (+0.2%)

Figure 7.2 and Table 7.2 reveal the dramatic impact of sandscaping in 2019 on beach sediment volume. This is most pronounced at Bacton Gas Terminal (+105% increase), where sediment more than doubled in the case study area (and where the majority of placed sediment was introduced), but also observable further down the frontage at Bacton (50% increase) and Walcott villages (77% increase). The 2019 changes to sediment volume in these three sampling areas are noticeably higher than interannual variability pre-sandscaping, and are statistically significantly different (independent t-test assuming unequal variance, to a 95% confidence interval, 2015-2018 vs 2019-2022) (Bacton Gas Terminal; $p=0.007$, Bacton; $p<0.001$, Walcott $p=0.004$). In contrast, changes to sediment volume at Happisburgh North and Happisburgh South after 2019 are not dissimilar to the

interannual variability pre-sandscaping, and are not statistically significant (to a 95% confidence interval, 2015-2018 vs 2019-2022) (Happisburgh North; p=0.57, Happisburgh South; p=0.89). Given Happisburgh is outside of the area of intended coastal protection from the sandscaping scheme, such findings are not surprising, but nonetheless highlight the distributional impact of the scheme in terms of the protection afforded to Bacton and Walcott, in comparison to Happisburgh.

With the exception of 2021 at Bacton (a 6% increase on previous year), the sampling areas at Bacton Gas Terminal, Bacton and Walcott have seen a decrease in sediment year on year since sandscaping was completed in 2019. Average yearly decline is -9% at Bacton Gas Terminal and -10% at Walcott, but a greater volume of sediment is estimated in the Bacton sampling area in 2022 (281,639m^3) than 2019 (274,999m^3). Although this suggests there has been a greater decline in sediment volume at Walcott than Bacton following sandscaping, estimates are based on LiDAR data sampled at different dates each year during the Winter season, and within a particular sampling area. In other words, a similar trend may be the case elsewhere at Bacton and Walcott, or at different times of the year. The considerable variability in sediment volume between Happisburgh North and Happisburgh South, which often see opposing changes year on year despite being close geographically, further highlight the uncertainty and variability in coastal change year to year. In conclusion, there has been a dramatic change in beach volume that has instantaneously built resilience to coastal storms at Bacton Gas Terminal, Bacton and Walcott. Sediment volumes are fluctuating, and placed sediment is gradually relocating along the coast over time, highlighting that the scheme, and associated physical resilience, is only temporary.

7.4.3 Perspectives on future managed realignment at Bacton and Walcott

The strongest cross-cutting theme from policymaker interviews, discussed at length and on multiple instances by all interviewees (regardless of whether they work in a local, regional, or national context) is the need to prepare now for a future managed realignment policy at Bacton and Walcott (for example code 'adaptation' in Table 7.1). Policymakers unanimously discussed the purpose of the sandscaping scheme as ultimately an opportunity to 'buy time' to prepare for adaptation:

> *"What was sort of woven throughout the business case that was submitted for the funding to Bacton and Walcott is the need to adapt and the need to start thinking about adaptation and that's really what the frontage needs to be considering"* ~ Regional policymaker

> *"It* (sandscaping) *was about buying time, and we kind of said it's like turning the clock back. But when we get, we'll get back to a situation where we're going to need to change and adapt. So we need to use this time wisely"* ~ Local policymaker

Policymakers stressed it was important to begin engaging with local residents on adapting to a managed realignment policy, and referred to the current Coastwise project in Norfolk (then known nationally as CTAP) as an opportunity to do this, which will involve developing adaptation or 'transition' plans for an area:

> *"We've reduced that risk, we've now given ourselves time, bought time, to really need to adapt the frontage and this is where I think CTAP can start to come in. And because one of the deliverables from CTAP is going to be transition plans amongst other things…So that's what we need to start thinking about how we are going to adapt this community"* ~ Regional policymaker

While local policymakers described discussions about adapting to managed realignment in Bacton and Walcott as in an early stage, policymakers also felt a sense of urgency is recognised by local residents on the need to plan for adapting to managed realignment:

> *"I think at the outset and in the early community engagement before the sandscaping was built, it was quite clearly highlighted…that this was a 20 year timeframe sort of project, and it was about buying time to allow communities to adapt. And so that message was clearly delivered"* ~ Regional policymaker

> *"They* (Walcott residents, parish council meeting in 2022) *wanted to talk about adaptation and the Parish Council…they were talking about the need to plan to adapt. You know, what do we need to do next. Which was music to my ears, to be perfectly honest, that they're thinking like that. Rather than just thinking 'oh, well, we're safe now' or 'when's the next Coast Protection Scheme'* ~ Local policymaker

However, these policymaker perceptions do not appear to reflect the perspectives of the majority of residents surveyed or interviewed here. The need to prepare now and plan for erosion risk after the sandscaping scheme's lifetime was not explicitly expressed by a single resident interviewee. Furthermore, an open-text survey question (n=58) asking residents if any actions should be taken now (other than sandscaping) to prepare for future coastal change found a third of responses (33%) called for more, or more maintained, hard defences. In addition, residents called for improved drainage or some other form of coastal management intervention. Only a handful of survey answers referred to community discussions or consultation, and no answers referred to adapting to managed realignment. For more elderly residents, should any property rollback or wider relocation form part of a managed realignment plan at Bacton and Walcott, there is a general perception this will be outside their lifetime, regardless of whether sandscaping is repeated or not. Interview data indicates that this group of residents is not unduly concerned about, or sees the personal relevance of, future coastal management post-sandscaping.

> "*If, once and if, they ever do decide that we won't be getting gas anymore and they don't change what they do there, then any kind of protection we get, oh, I can see it will just go, but again I'm thinking it's not going to be in my lifetime*" ~ Bacton resident

> "*People were 'oh ok, the sand's here, the sea's gonna last 20 years'. Lot of old people were saying, 'well, that will see me out. I'd be happy with that'*" ~ Walcott resident

One resident expressed a strong desire not to move, regardless of the future situation of erosion risk or an offer of property planning rights elsewhere (as was the case in the 2012 Happisburgh pathfinder programme) (Frew, 2012). Their reflections underline the strong sense of place many residents feel to Bacton and Walcott:

> *"In 10 years time if they turn around and say 'oh your house is right on the edge of the cliff, and you've got to be moved', I'd rather they spent the money to keep the cliff farther out to sea. Or they do the seawalls in good maintenance, and for me to see my time out here, 'cause I'm settled here and I'm happy here. And again, as you get older, being uprooted is even harder. To turn around to a young couple with a couple of kids or just a young couple or even a middle-aged couple and say, 'well, we're gonna offer you your full right to your house and then you can go and move to somewhere else'. 'Yeah, OK fine'. They might be able to do that, by try moving a 70/80 year old person out of their property, they'll turn around and say 'I'll drown here'. They will"* ~ Walcott resident

Even amongst younger residents, a common perception was that erosion risk would not return immediately post-sandscaping, and that the residual life of the sea wall and other currently redundant hard defences at Bacton and Walcott would buy an additional amount of time so that this group of residents will also not be directly affected. This was a view expressed both by interviewees living a few streets inland and on the immediate coastal frontage:

"*Even if it wasn't replenished, and the seawall becomes more exposed again, then it's still probably another 10-15 years before the seawall would be breached*" ~ Walcott resident

"*There's a government website about flooding risk… and it was something like 50 years before where our house might be affected. Well, that's out of our lifetime. That's somebody else's problem, you know*" ~ Bacton resident

"*We'd have to move. Yeah, and I certainly know at Happisburgh people have been assisted in moving. So I imagine that if it came to that, there would be something like that, but we don't expect it in our lifetime, really*" ~ Walcott resident

In summary, there is an urgent need, according to policymakers, to prepare for managed realignment at Bacton and Walcott, and sandscaping is framed as a vital project that has enabled a space for anticipatory adaptation to future erosion risk. However, across different generations at Bacton and Walcott, it appears this sense of urgency expressed by policymakers is not similarly felt by many residents, and that sandscaping has taken the question of coastal management outside of local residents' direct concerns, at the time interviews were conducted (Autumn 2022, year 3-4 of the sandscaping scheme). While largely confident that the frontage will remain protected, residents are at the same time fearful of what a managed realignment policy might entail, and refer to the rollback that can be witnessed at present at Happisburgh (explored in Chapter 6). There is a hope by many local residents that sandscaping has bought enough time that residents do not have to be directly confronted by a managed realignment policy.

7.4.4 Perceived role of local residents in coastal decision-making

Policymakers and local residents also appear to have different perspectives on the role of local residents in managing coastal change, as the Bacton-Walcott frontage moves to a managed realignment epoch. Policymaker interviewees, particularly those working at a local level, expressed a desire for local residents to be heavily involved in Coastwise, describing transition plans as something that should be ‘co-created’ with local communities. Furthermore, it was conveyed that the local community, alongside local businesses, share a certain level of responsibility in coastal adaptation

> *“I'm hoping with our stakeholder engagement theme, that's kind of running throughout all these different actions, communities are going to be involved from the start. We want co-creation and collaboration when it comes to these transition plans. So yeah, involved throughout in every aspect”* ~ Regional policymaker

> *“A huge emphasis is going to be placed on North Norfolk and East Riding of Yorkshire* (Local councils receiving CTAP funding) *to actually work with and engage communities, that the whole aim is to look at actually co-creating the future, the future of that coast”* ~ National policymaker

> *“It's about everybody playing a role, and people taking and businesses taking certain levels of responsibility. So it's not local government doing it to people, but it's actually everybody”* ~ Local policymaker

When asked what the key challenges were to facilitating coastal adaptation under a managed realignment SMP policy, interviewees at different levels of government reflected on challenges to facilitating community acceptance of such a policy, and challenges to practically implementing a nationwide, replicable, policy: time, trust and place attachment were all highlighted as key barriers.

"In short, it's not easy and the time it takes cannot be underestimated. And so what goes with co-creation is that joint respect and understanding, and that takes a certain amount of time because that requires trust across not only the coastal managers but also the communities that they're working with" ~ National policymaker

"I think it comes back to the community engagement and the co-creation. And I think ultimately it's about the acceptance of change" ~ National policymaker

"Probably one of the biggest ones to overcome is the human element and sort of the attachment to place" ~ Regional policymaker

But regional and local policymakers also highlighted the lack of centralised policy funding and guidance on coastal adaptation is a significant challenge:

"The difficulty is because of the funding, political and social issues, we can't yet have a plan that definitively says we will help those people roll back and relocate because it's not currently supported, so it's a bit cart before the horse or chicken and egg – whatever metaphor you want to use. We'd love to have a plan, but unless the plan is underpinned by appropriate funding and legislation, we can't really have the plan. So that's the difficulty that we need to solve" ~ Regional policymaker

"Which is always a challenge to do that sort of thing, but sort of co creating what? What might we need to do. And we've been sort of tasked with creating transition plans, but we've, there's no rulebook to say what, that is not defined in any way." ~ Local policymaker

Meanwhile, policymakers described the work Coastwise would support at a local level, which focused on a need to increase community knowledge and awareness of the risks of coastal change:

"One is around sort of improving coastal literacy, coastal understanding about the coast, people understand what's going on, why, that side of it. There's understanding the baseline. So that's people's perceptions, thoughts, hopes and dreams, you know. But it's also about the demographics and all of that element and also the geographical. So actually understanding the place better

and it's then about really it's co-creating sort of a way forward with the community" ~ Local policymaker

"We probably got a piece of work on people in place and they're preparedness, which is obviously going to have a really strong stakeholder engagement theme running through it, whether it's guidance and a real educational element when it comes to living on a dynamic coast, that kind of thing" ~ Regional policymaker

Although engagement in Coastwise had not begun at the time of interviews with local residents, interviewees described a more limited role in coastal decision-making than policymaker interviewees. Picking up litter, acting as flood wardens, or supporting hard defence schemes at a property level (if directly living on the frontage) were some example roles suggested by resident interviewees.

"Well, I think I think, You know, well, we're always picking up litter off the beach. ~ Walcott resident

"So that's the sort of individual responsibility that you, you can choose to pick it, or just leave it to get worse. So that's one thing. I mean, there's not. We keep doing our little bank haven't we, you know, in our house. We've been sort of redoing our garden and creating a little bank, Which should we be flooded, might help keep the water away from the house, and help it go down the road, rather than, in a drain process" ~ Walcott resident

When prompted on whether residents could (or should) be involved in decision-making about managing coastal change at Bacton and Walcott, local residents described providing input to coastal management proposals, but reflections did not describe the level of responsibility (co-creation of adaptation plans) as envisaged by policymakers.

"You know, at the level that you've seen today, you know I'm not, not particularly technical, but I've got a keen interest. So yeah, I would certainly be part of discussions or would be willing to do it" ~ Bacton resident

"I think in terms of leading it has to be the Council, and the local Council, because if local people can't live, it's going to be their issue, to have to sort out isn't? It if they've suddenly got a population - and I don't know how many people living in Bacton, 3,000 or whatever - who are not able to live there. Then we've got an issue" ~ Bacton resident

There is some scepticism amongst resident interviewees of public consultation (which relates to findings in Chapter 6). Furthermore, in response to a question about managing coastal change while sandscaping is in place[17]: 14% of survey answers articulated not knowing or feeling unqualified to answer, suggesting that residents may feel there is a limit to which they can contribute to decisions about coastal management on their local frontage.

"I think there will always be people who will have an opinion on it and will want to be involved, although how effective that kind of thing is I don't know." ~ Bacton resident

"I think that design of local endeavours to secure this sand and the coast and all of that should be definitely designed by specialists who know the impact of those things or who at least have done the research, you know… I think it does need to be like coastal specialists, you know, geography specialists" ~ Bacton resident

'Not my speciality – leave it to the expert' (Survey response to 'Other than sandscaping, do you think any actions could be taken now to prepare for future coastal change in your village (and are you aware of anything happening in your village at present?)

In conclusion, there is a widespread desire amongst coastal policymakers working at all levels of government for community involvement in preparing for a managed realignment policy at Bacton and Walcott. Survey and interview data of Bacton

[17] Question 17: Other than Sandscaping, do you think any actions could be taken now to prepare for future coastal change in your village (and are you aware of anything happening in your village at present?) (total responses to question= 58)

and Walcott residents does not suggest that residents feel this collective responsibility, however, at this moment in time. Furthermore, a few residents expressed doubt on the effectiveness of public consultations in coastal management. Policymaker interviewees described increasing knowledge and awareness of coastal risk, in particular, as important objectives of community engagement through Coastwise.

7.5 Discussion

7.5.1 Perceived sense of security from coastal change

Approximately three years on from the introduction of sandscaping at Bacton and Walcott, the results highlight three significant, and related, perspectives of local residents: an expectation that Bacton Gas Terminal will continue to be protected, a hope that sandscaping will be repeated (or other coastal defences reinstated), and no strong sense of urgency (in contrast to coastal policymakers), to prepare now for coastal change post-sandscaping. Although there are different views amongst local residents about how quickly redundant defences would deteriorate, and how soon a significant risk of erosion would return, a contrast can nonetheless be seen between policymakers and local residents on the need for anticipatory adaptation to managed realignment. For policymakers, sandscaping has bought time to prepare for managed realignment, whereas for residents, sandscaping has bought time to postpone it. Meanwhile, Table 7.2 and Figure 7.2 shows the immediate, dramatic change in sediment volume at Bacton Gas Terminal and the villages of Bacton and Walcott, found to be statistically significant (2015-2018 vs 2019-2022), but this placed sediment is gradually redistributing over time, and the protection from flood and erosion risk afforded by sandscaping is only temporary.

Research on coastal risk management worldwide has demonstrated a link between enhanced physical protection to flooding and reduced social risk perceptions or resilience (Logan et al., 2018; Brown et al., 2023). This has been termed the ‘levee effect’, where lack of exposure to flood events increases social vulnerability to future events (Di Baldassarre et al., 2015). The implementation of higher sea walls and greater flood defences in New Orleans, United States and in Japan was argued to decrease societal risk perception, and contribute to a false sense of security for extreme events (Di Baldassarre et al., 2015; Plumper et al., 2017; Boret and Gerster, 2021; Rafliana et al., 2022). Furthermore, communities protected by infrastructural engineering are less aware of flood risk (Ludy and Kondolf, 2012) and have lost an important feedback loop for learning, through exposure to flood events, which is argued to be critical for building social resilience (Colten and Sumpter, 2009; Logan et al., 2018, Plumper et al., 2017; Martinez et al., 2020). Indeed, the concept of learning appears prominently in this thesis’ definition of social resilience (section 3.2.1, Maclean et al’s (2016, p. 523), and in the categories of resilience explored in the literature review (Table 3.1). Other authors argue the relationship between awareness of coastal change and risk perceptions is not clear cut, and the observed maintenance of defences can be used as evidence by communities - already highly aware of coastal issues – to reinforce a desired sense of security from the risk of coastal change (Luis et al., 2015). The latter findings appear to have relevance in this context, where Bacton and Walcott residents show high awareness of issues of coastal change and rollback occurring elsewhere on the Norfolk coast. Therefore in this case study context, the impact of sandscaping on coastal risk perceptions appears to be not reduced awareness and learning, but reduced prioritisation and personal relevance of risk.

Recent research on UK public attitudes to climate change adaptation (Harcourt and Dessai, 2023; Harcourt et al., 2023) argues that whilst concern for climate change is increasing, it can be superseded by what is perceived to be more immediate societal impacts. In this case study, the immediate relevance of the war in Ukraine and the cost of living crisis, explicitly mentioned by multiple resident interviewees, similarly appears to demote residents' concerns about future coastal change. Furthermore, some residents reflect that the risk of coastal erosion will only return to significant levels outside of their lifetime, a perception similarly observed in other high-risk, undefended coastal communities in South Portugal (Costas et al., 2015; Domingues et al., 2017). This relates to longstanding research highlighting the challenge of psychological distancing in relation to climate change (Lorenzoni et al., 2007; Harcourt and Dessai, 2023) where individuals express lower concern for impacts they perceive will occur in the future (Spence et al., 2012). Previous research on public perceptions of coastal adaptation (Few et al., 2007) argue that public willingness to engage in participatory decision-making is typically more challenging in coastal contexts, where coastal risk may not be immediate. Additionally, although perceived longevity of coastal nature-based solutions (and implications for adaptation) has not been explored, psychological distancing has been observed in coastal communities in relation to the risk of coastal erosion, (Domingues et al., 2017), suggesting that like coastal defences, the deployment of nature-based solutions may inadvertently work in a similar way to reduce concern of future coastal change.

These findings highlight a potential risk of transformative coastal management approaches such as sandscaping on maladaptation, and the tensions between transformation and maladaptation, a link made in the conceptual framework. Despite the significant socio-economic benefits of sandscaping in the present day and an opportunity to proactively prepare for adaptation to managed realignment, the results also highlight a risk of maladaptation if sandscaping results in less community buy-in for future adaptation. Naylor et al., (2019) and Sayers et al., (2022) argue there is currently a strong risk of maladaptation in England where 'hold the line' policies are continued in areas it can't be sustained indefinitely, and that a desire to avoid blight in coastal towns is leading to delays in adapting to managed realignment (Brown et al., 2023). This is notwithstanding many other 'lock-ins' that have been identified as entrenching 'business as usual' in coastal management in England, such as lack of national funding and clearly defined roles for coastal adaptation (Groen et al., 2022). Therefore, of particular relevance to research question 1 on geomorphological change and research question 2c on perceptions of future coastal change, sandscaping could be both transformative and maladaptive, depending on the dimension (e.g. physical or social) and timescale studied. It is likely that the findings in this case study are rooted in the time period with which they were analysed (year 3 of the sandscaping scheme in 2022, amidst the backdrop of the war in Ukraine and emerging news stories on the terminal repurposing to hydrogen). Further research is required to explore perceived responsibility and urgency of coastal adaptation later on during the sandscaping scheme, and once discussions between policymakers and local residents on adapting to managed realignment at Bacton and Walcott are formally underway, through Coastwise or otherwise.

7.5.2 Uncertainty

The resident and policymaker perspectives reveal sandscaping has bought additional uncertainty to coastal management at Bacton and Walcott. This includes geomorphological uncertainty, as shown in Figure 7.2 and Table 7.2, in terms of how long placed sediment will remain at the Bacton and Walcott frontage, but also uncertainty about the future of Bacton Gas Terminal. Community engagement in Coastwise is likely to be set against a cycle of media speculation about Bacton Gas Terminal repurposing as a hydrogen or CCS site. This may form a distraction to policymaker-initiated conversations on managed realignment, and highlights the challenge of introducing innovative nature-based solutions like sandscaping in the short-term, for coastal frontages that will require managed realignment in the long-term. Whether a second sandscaping scheme is funded by terminal operators, and crucially what coastal area this may cover, has much wider national and international-scale considerations, given the presence of the nationally important Bacton Gas Terminal within this frontage, and highlights the spatial and temporal trade-offs in coastal management that has similarly been highlighted in previous research (Cooper and McKenna, 2008; Brown et al., 2023). As speculated by interviewees, this includes the role of Bacton Gas Terminal in the UK's future energy portfolio, and international geopolitical factors that have a bearing on UK energy security. This raises issues of power and justice, in how, by whom, and at what scale, coastal management decisions are made, and who decides, who causes, and who feels the effects of climate change.

Studies internationally of communities facing coastal retreat similarly emphasise the relevance of uncertainty as a barrier to adaptation (Costas et al., 2015). In New Zealand, Hanna et al., (2020) argue an 'uncertainty contagion' can be seen, whereby numerous forms of uncertainty interplay and spiral into more uncertainty for where, when, and how coastal adaptation to managed retreat (a term used interchangeably with managed realignment) can be facilitated. In this case study, the introduction of sandscaping has added further uncertainty, of both geomorphological and social dimensions, to future adaptation under a managed realignment scenario. Hanna et al., (ibid) argue manifestations of uncertainty in managed retreat ultimately all stem from political inertia on a lack of funding and clarity on how adaptation can be financed and supported, a point similarly raised by local and regional policymaker interviewees in this chapter. The challenge, Hanna et al., (ibid) argue, is where uncertainty on coastal retreat builds up to such an extent that it begins to cause paralysis. This can be seen at an individual level in Fairbourne, Wales, where the media report of some residents not spending money beyond essentials, given the unknown on when and where they may need to relocate, and how much this will cost (BBC, 2022).

Therefore, the implementation of sandscaping has increased physical resilience but also added numerous forms of uncertainty, suggesting that innovative nature-based solutions like sandscaping can be both resilient and uncertain. This chapter has also highlighted the inter-connected nature of uncertainty in relation to sandscaping, with many feedbacks between social perspectives and observable geomorphological change. Although debates within literature on the link between resilience and uncertainty are explored in this thesis' literature review (section 3.2.5), the prominence of uncertainty as a theme in the empirical findings of this chapter suggest this could be represented in the conceptual framework (a finding revisited in Chapter 8).

Across the interview data, a divergence can be seen in how policymakers and local residents respond to such uncertainty. With a responsibility to manage erosion risk for the frontage, policymakers articulate it is impossible to give a date on when Bacton and Walcott will transition from 'hold the line' to 'managed realignment', and that using a trigger-based scenario in community engagement and community transition plans is more practical (such as when levels of placed sediment from sandscaping fall below a certain threshold, or when overtopping of the seawall occurs to a significant extent). The challenge for local policymakers is that local residents use a personal lifetime, rather than a trigger-based scenario, in their perception of coastal risk. Whether a sea wall is decommissioned in 10 or

30 years' time makes a sizeable difference at an individual level to a local resident's future, in terms of whether they will be directly affected by managed realignment or not. Going beyond an individual framing, and using an intergenerational justice narrative to convey the importance of a community transition plan for future generations living in the area, may be useful for policymakers to persuade local residents on the need to collectively prepare transition plans for future coastal change. In relation to this, although this study elicits views of adults living in Bacton and Walcott, further research that examines the views of children and the sandscaping scheme may be insightful, given that campaigns such as the Schools Strikes for Climate shows that younger generations show high levels of concern about future climate impacts (Hickman et al., 2021).

7.5.3 Community involvement in coastal decision-making

This chapter highlights potential challenges to involving local residents in coastal adaptation planning, with residents expressing little perceived responsibility in coastal management decision-making, alongside doubt in public consultations and laymen's knowledge of coastal issues as found in Chapter 6. Residents may not want to be engaged in coastal issues to the extent envisaged by policymakers; co-creating adaptation plans for the Bacton and Walcott frontage post-sandscaping. To address this, policymaker interviewees articulated the need through CTAP to improve coastal literacy (knowledge and awareness of coastal change) across Norfolk coastal communities. The conceptual framework (section 3.5) presents three key dimensions to building adaptive capacity; the policymaker interview data in this chapter appears to suggest that there will be a greater focus through Coastwise on building capacity to prepare, which is one dimension of building capacity in the conceptual framework, rather than other dimensions (a finding revisited in Chapter 8).

7.6 Conclusions

An intervention (sandscaping) to bring about transformative change in managing the coast (a temporary respite from immediate erosion risk to a later requirement for managed realignment) may inadvertently create additional challenges in the longer-term transition from ‘hold the line’. This includes decreased risk perceptions of future coastal change, through reduced urgency and perceived personal relevance of risk, alongside increased uncertainty and complexity in managing risk for Bacton Gas Terminal, with competing national and local-level, short-term and long-term coastal policy interests. This chapter has therefore provided a case study example of additional challenges to the use of nature-based solutions in the short-term, despite its immense benefits of coastal protection. While sandscaping has provided time to prepare for managed realignment, there is a risk of maladaptation on longer timescales (i.e. 20+ years) through decreased societal risk perceptions and relevance of coastal change. There is a need for further community engagement now, so that short-term physical resilience is not achieved at the expense of building longer-term social resilience to coastal change. Wide-reaching, sustained community engagement on future scenario planning, that adopts an intergenerational justice framing, could be one way in which Coastwise can facilitate community buy-in for discussions on managing future coastal change.

As the last empirical chapter of the thesis, this chapter provides insights on the challenges to anticipatory adaptation to managed realignment, which will be of relevance to other coastal areas and climate impacts preparing for future climate risk. It can be seen from the empirical data that a ‘winners’ and ‘losers’ framing, typical in distributional justice literature (section 3.3.4) is a limited framing to explain the scale-sensitive dynamics in this context. The following Discussion and synthesis chapter (Chapter 8) examines cross-cutting themes emerging from the empirical chapters (5-7), for the purpose of exploring the main empirical findings of the research, alongside a review of the thesis theoretical and methodological contributions.

Chapter 8: Discussion and synthesis

8.1 Introduction

This thesis examines the social and geomorphological impacts of the Bacton-Walcott sandscaping scheme, and social perceptions of wider coastal change. It uses an environmental justice lens, to assess the implications of sandscaping on building longer-term resilience to coastal change (i.e. beyond sandscaping's 15-20 year lifespan). Coastal adaptation and a managed realignment SMP policy is explored in this thesis through two very different case study contexts, one with time (Bacton and Walcott, with a temporary respite from erosion risk due to sandscaping, Chapters 5 and 7) and one without (Happisburgh, Chapter 6). Comparing the two contexts provides insights on transformation, maladaptation and anticipatory adaptation to coastal change, which is reflected on in this chapter.

This discussion chapter firstly identifies and presents the cross-cutting themes that arise across the three empirical chapters (Chapters 5-7) in section 8.2. It also maps visually the empirical findings and key barriers onto the conceptual framework via 'zoomed in' annotations to the conceptual framework diagram (Figures 8.1-8.5), that are subsequently presented altogether in a modified conceptual framework in Figure 8.6. Further insights on the theoretical contribution of the work is explored in section 8.3,in relation to the concepts of transformation, resilience, maladaptation (8.3.1) and environmental justice (8.3.2). Methodological contributions are explored in section 8.4. Lastly, this chapter considers the limitations of the thesis and areas of future work (section 8.5).

8.2 Revisiting the conceptual framework in light of key empirical insights

The conceptual framework (detailed in section 3.5) draws upon the fields of resilience, environmental justice and adaptation to explore the impacts of sandscaping and implications for coastal resilience. Specifically, Figure 3.6 presents the critical influence of social, environmental, spatial and temporal components (shown as green boxes) on transformation and maladaptation. While the connections between social, environmental, spatial and temporal components are visually illustrated in Figure 3.6 through connecting lines, findings from the empirical chapters suggest greater nuance could be added to the framework on the complexity of the relationship between concepts. This section draws out some of the key findings across the empirical chapters, and uses the conceptual framework to highlight the main complexities, trade-offs and scalar conflicts emerging from the research. This is done by zooming in on specific parts of the conceptual framework to illustrate where these connections and complexities arise.

In summary, five modifications to the conceptual framework are proposed. These are;

- A feedback loop to denote the influence on social perceptions of witnessing environmental change, and the role of geomorphological uncertainty (Figure 8.1);
- Greater nuance in the denotion of social perceptions, that vary within and between groups (Figure 8.2);
- More specific representation of the complexity of the relationship between time and resilience, that both too much and too little time risk undermining social resilience (Figure 8.3);

- A negative feedback loop of the interconnected barriers to adaptation of lack of information, communication and trust (Figure 8.4);
- The significance of lack of policy funding and guidance in increasing risk of maladaptation, at the expense of transformation (Figure 8.5).

These proposed modifications are explored in turn, and subsequently mapped all together onto a modified conceptual framework in Figure 8.6.

8.2.1 The influence of environmental change on social perceptions

The influence of observed changes in the physical environment on public perceptions is prominent across the empirical chapters. Residents draw upon physical observations of how the Bacton-Walcott frontage is changing to inform their perceived effectiveness of the sandscaping scheme (Chapter 5) and perceptions of future coastal risk (Chapter 7). Meanwhile in Chapter 6, Happisburgh residents describe the lived experience of coastal change, witnessing the loss of several metres per year in areas of the village such as Beach Road. It is also apparent in Chapter 6 how the lived experience of witnessing erosion rates shapes residents' perceptions of adaptation options for the village. The link between social and environmental components is therefore now represented in more detail in the conceptual framework as a feedback loop (shown in Figure 8.1), rather than a linear relationship (as previously). While much research exists within socio-ecological systems literature on the interdependency between the social and natural world, as reviewed in section 3.2.2 (for example Adger (2000); Greg-Lloyd et al., 2013; Virapongse et al., (2016)), research specifically on feedbacks between environmental change and social perceptions in a flood or erosion context are typically quantitative modelling assessments (Di

Baldassarre et al., 2015; Logan et al., 2018), with a paucity of qualitative research, to which this thesis contributes.

8.2.2 The added complexity of uncertainty

The results chapters reveal that geomorphological uncertainty in particular has a bearing on the views of local residents and policymakers on managing coastal change. In the empirical chapters, this manifests in terms of uncertainty on the lifetime of the sandscaping scheme (Chapters 5 and 7) or uncertainty in where, when, and by how much, coastal erosion will affect Happisburgh (Chapter 6). The average rates of coastal retreat (1.9 m yr^{-1} (+/- 1.4m) at Happisburgh North and 1.1m yr^{-1} (+/- 1.0m) at Happisburgh South, over an 850m sampling area from 2015-2022) is fast but also highly variable, e.g. great change in one year or at one location, but little discernible change the next. Uncertainty is not represented in the original conceptual framework diagram, and solely acknowledged in the description of the conceptual framework (section 3.5). Therefore, uncertainty is now also incorporated in the above proposed feedback loop between the social and natural world. Figure 8.1 illustrates this proposed modification in blue, with a feedback loop between the green ‘social’ and ‘environmental’ boxes, that also links to a new blue box denoting the influence of uncertainty.

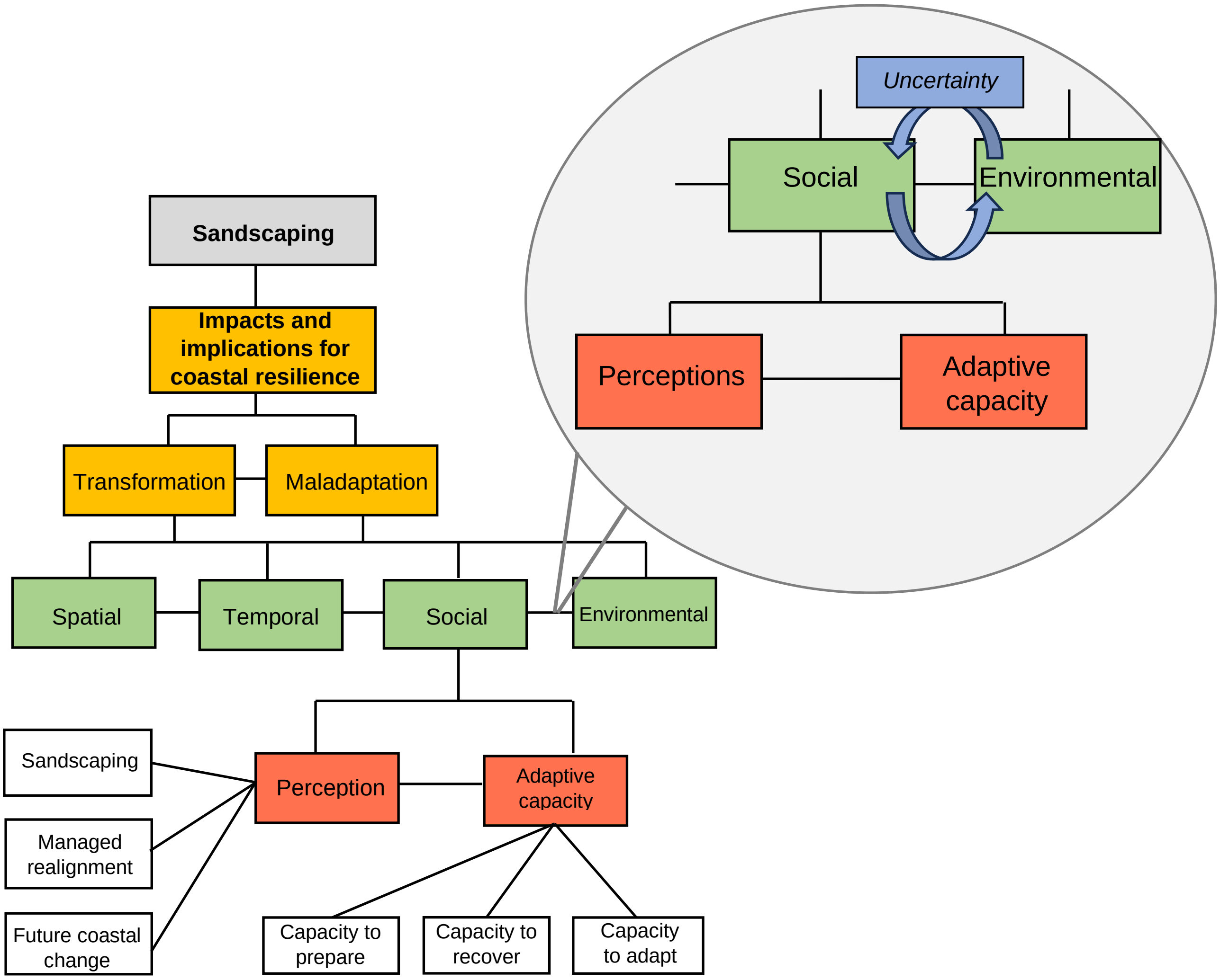


Figure 8.1 Proposed modification (inset, top right) to the conceptual framework (Figure 3.6) to represent the connection between social and environmental components as a feedback loop rather than a linear relationship, influenced by uncertainty associated with geomorphological change. Proposed modifications are shown in blue. Boxes in yellow refer to resilience, boxes in green refer to scalar elements of environmental justice, and boxes in red refer to perceptions of adapting to coastal change. Boxes in white refer to factors that influence adaptive capacity (bottom of diagram) or different subjects of coastal change (left of diagram).

8.2.3 Wide-ranging views within and between social groups

One of the most apparent findings across the empirical chapters, and relating to research questions 2a, 2b, and 2c on social perceptions, is the range of opinion within local communities on managing coastal change. As outlined in Chapter 5, residents of Bacton and Walcott had mixed views about the sandscaping scheme, how it has impacted the village, and how effective it is. Meanwhile Chapter 6 reveals differing views of Happisburgh residents on rollback of the village car park, and whether the village should continue to campaign for coastal defences. While there appears to be greater similarity of views amongst Bacton and Walcott residents in Chapter 7 on the future of the frontage post-sandscaping, residents demonstrate different strengths of opinion on the likelihood the frontage will continue to be defended. These chapters therefore demonstrate the breadth of opinion on coastal issues. Furthermore, views on sandscaping and managing coastal change vary greatly, in that there are individuals within the same village that hold strongly opposing opinions. For example, there are residents in Chapter 5 deeply satisfied and others dissatisfied with public engagement leading up to the sandscaping scheme, and residents of Happisburgh in Chapter 6 that feel the coast should be left to erode versus those that strongly argue further intervention is needed. This complexity in the range of diverging social perspectives is not a nuance currently presented in the conceptual framework.

This is significant because building a community consensus to adaptation plans for a village under a managed realignment policy, which is a key objective of the current Coastwise project, is therefore likely to be very challenging. In Chapter 7, policymakers describe an ideal future process in Bacton and Walcott where communities develop a shared vision of the frontage, but Chapter 6 shows, with the example of Happisburgh car park, the difficulties of achieving community agreement on rollback of a community asset. At the time of writing (Spring 2024), plans to reroute and eventually relocate Happisburgh village car park have been approved by NNDC (EDP, 2024), after years of discussion and objections by some local residents. This suggests sufficient time will be needed for discussions as part of Coastwise, where views may differ on how to repurpose at-risk land. As Chapter

6 concludes, Happisburgh residents are still disputing a policy of managed realignment, nearly 20 years after the SMP change; this demonstrates the challenges of enacting a disputed policy, which currently is being discussed by residents in the context of greater clarity at a national level, including finance and support (discussed later in this section as key barriers).

A particular challenge in the variety of social perceptions evident across the empirical chapters lies in how perceptions of impact shift over time as management approaches are introduced. Chapter 5 reveals the implementation of sandscaping has shifted perceptions of impact for local residents, where some Bacton and Walcott residents have moved from fearing direct flood and coastal erosion events (such as inundation, house shaking, property damage), to fearing the inconvenience of wind-blown sand (as a result of the protection afforded by sandscaping). There has therefore been a transition, for some residents, in the scale or severity of impact that they perceive or experience. However, how impacts and risk are (subjectively) perceived by individuals, and what people perceive as tolerable, can create challenges for coastal managers if potential solutions such as sandscaping are perceived in a negative manner, despite flood or erosion protection. It can equally be seen, in the perceptions of other residents, that the negative impact of wind-blown sand is temporary, given the longer-term benefit of peace of mind by living alongside a defended frontage. Chapter 6 outlines that the mental health impacts of Happisburgh residents living alongside an undefended frontage was a prominent theme.

Chapters 6 and 7 also highlight that views vary between residents and policymakers, and amongst policymaker interviewees (most notably between national and regional/local policymakers), in terms of current challenges to coastal management policy. This is encapsulated by two additional boxes in the conceptual framework, to highlight that views and lived experiences are not homogenous, and will differ across and within different groups. While the thesis literature review documents the variety of factors that shape public perceptions on adaptation (section 3.4.3, summarised in Figure 3.5), the empirical results show perspectives can be opposing even within a particular village. Two additional blue boxes highlighting this nuance are therefore proposed underneath the 'social' green box in Figure 8.2.

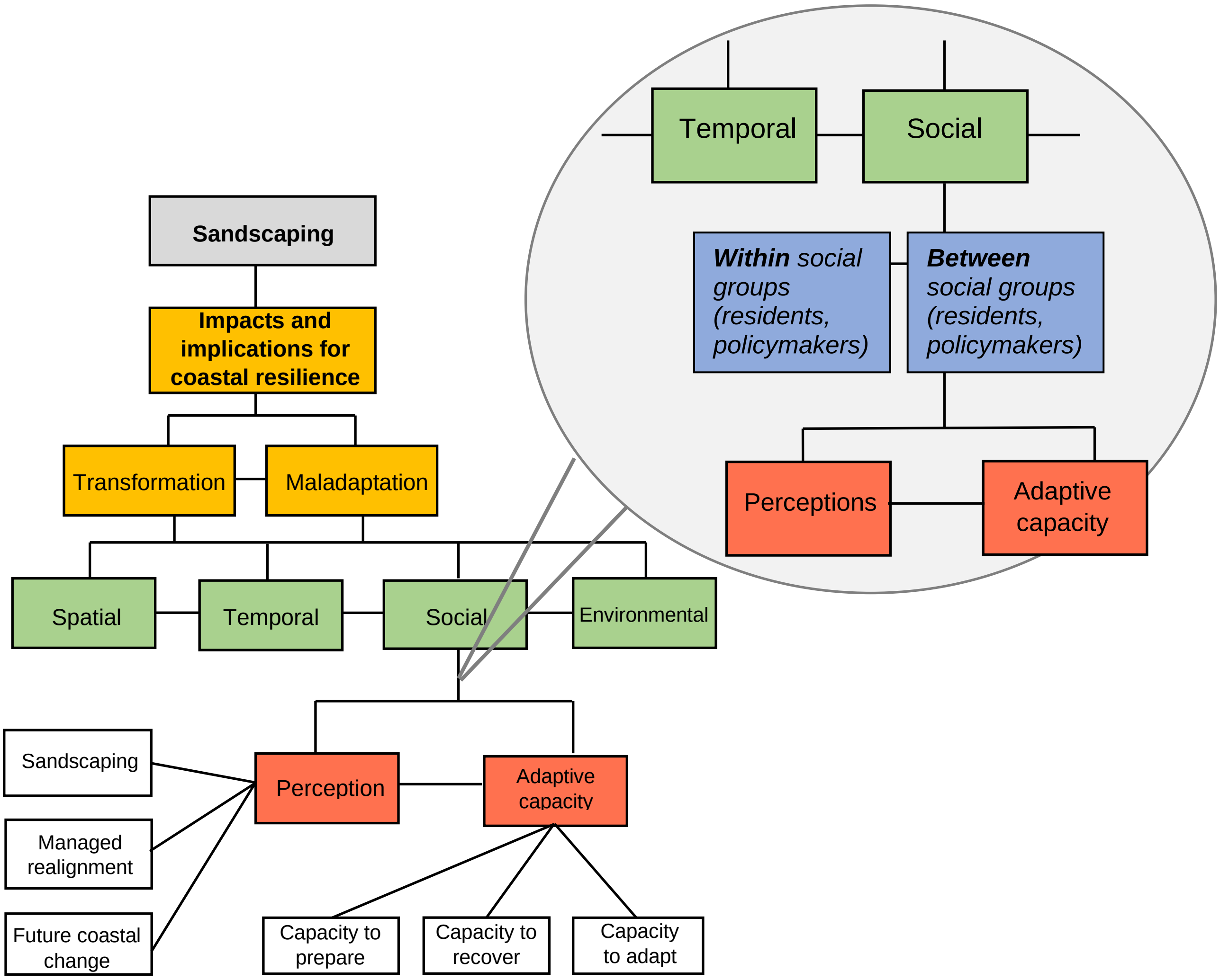


Figure 8.2 Proposed modification (two additional boxes, inset, top right) to the conceptual framework to represent the tensions and differences in views within and amongst social groups included in this research (residents and policymakers). Proposed modifications are shown in blue. Boxes in yellow refer to resilience, boxes in green refer to scalar elements of environmental justice, and boxes in red refer to perceptions of adapting to coastal change. Boxes in white refer to factors that influence adaptive capacity (bottom of diagram) or different subjects of coastal change (left of diagram).

8.2.4 The relationship between time and resilience

Empirical results show the importance and consequence of time, with regards to building social resilience to coastal change. Findings in Chapter 6 show the importance of sufficient time to discuss adaptation options and build trust within communities. On the other hand, Chapter 7 shows the challenge of a long lead-in time, in terms of persuading Bacton and Walcott residents of the importance and urgency of anticipatory adaptation to future coastal risk post-sandscaping. There is therefore a conflict between relevance and urgency: if urgency to adapt to coastal risk is removed, does it remove relevance of adaptation to coastal change? This finding, that both sufficient and insufficient time risks undermining social resilience, and risks maladaptation, adds nuance to the relationship between time and resilience, which is now mapped in blue on the conceptual framework diagram (see Figure 8.3).

Undefended coastal areas across the UK have a declining window of opportunity for anticipatory adaptation, where accelerating climate risk is being met with national policy inertia, as highlighted by local and regional policymakers in Chapters 6 and 7 (discussed later in this section as a key barrier). This relationship between time and social resilience was found across the adult residents interviewed and surveyed in this research. However, different generations (for example young people) may be more concerned with future coastal change impacts, and perceive to a greater extent the relevance of discussing a post-sandscaping frontage far in advance (i.e. before the sandscaping scheme reaches the end of its lifetime) than the participants in this study. Further research, drawing upon the perspectives of younger generations (that was outside the scope of this study), could further unpick the complexities of the relationship between time and social resilience, across generations.

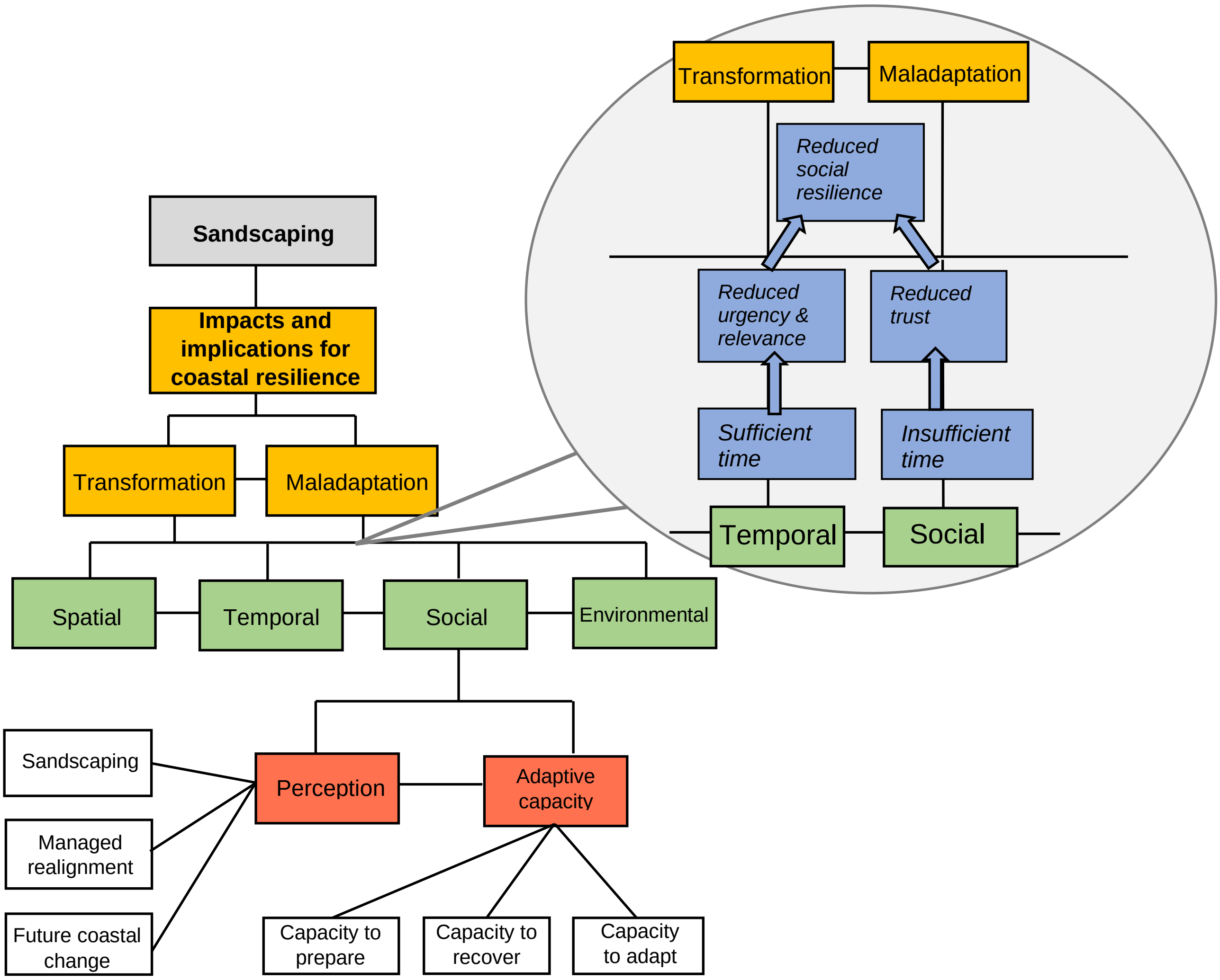


Figure 8.3 The empirical chapters contrastingly show that too much time and too little time risk undermining building social resilience, through different mechanisms. This finding adds nuance to the relationship between time and resilience, on the conceptual framework diagram. It is important to highlight the complexity in relation to time and resilience, in that there are two opposing trajectories that nonetheless lead to a similar outcome. Proposed modifications are shown in the blue boxes (inset top right). Boxes in yellow refer to resilience, boxes in green refer to scalar elements of environmental justice, and boxes in red refer to perceptions of adapting to coastal change. Boxes in white refer to factors that influence adaptive capacity (bottom of diagram) or different subjects of coastal change (left of diagram).

8.2.5 Key barriers to adaptation – information, communication and trust

The empirical chapters show a clear link, and significance of, a perceived lack of information and communication, and trust, among some of the study participants.

Lack of information on coastal change, and how coastal change is communicated to local residents, are related recurring findings across all three empirical chapters. In Chapters 5 and 6, Bacton, Walcott and Happisburgh residents unanimously call for greater information about how their coast is changing, e.g. how sandscaping is performing geomorphologically (Bacton and Walcott study participants), or when and how rollback, the Coastwise project, and other initiatives relating to managed realignment, would occur (Happisburgh participants). The data suggests a perceived lack of information on coastal change contributes to doubt or distrust, among local residents, in how coastal change is managed by local government, national government, or other key stakeholders. For example, a perceived absence of prominent public communication by NNDC or the terminal operators on how sandscaping is performing may have contributed to doubt amongst residents that the scheme will last for 20 years (Chapter 5). Of significance is whether other communication sources, particularly the media, fill this perceived paucity of information. Chapters 5 and 7 report of regular media speculation, mentioned by local residents, about how much sand has been 'lost' at the sandscaped frontage, or the future of Bacton Gas Terminal. In Chapter 6, policymakers commented on media articles in January 2023 that erroneously inferred from NNDC council meeting minutes that at-risk residents would be offered a form of property compensation through CTAP.

A further complexity is that the relationship between information, communication and trust varies from one resident to another. Contrasting perspectives are apparent in each chapter. For example in Chapter 5, where some local residents and policymakers recounted numerous community engagement events about the sandscaping scheme (before the works began), that were not recognised in the reflections by other local residents. Chapters 5 and 6 show that even where communication and information on coastal change exist, an individual's values and their perceived trust in local authorities has a bearing to the extent to which available information is accepted. Therefore, communication sources and pathways are also found to be a key barrier to adaptation in this context. This also raises a question of 'who' within the community is reached by communication or engagement channels. The data appears to suggest that elected members within the community, or those within established groups, such as parish councils, are more engaged in communication on sandscaping or coastal issues from local authorities. Therefore, differences of views on managing coastal change, which is notable across the empirical chapters, may relate to 'who' receives 'what' communication sources. That parish councils are engaged in discussions on coastal change with local authorities to a greater extent than residents is significant, given that Chapter 6 indicates parish councils are perceived by some residents as not necessarily representative of wider community views. This is important, given that high levels of trust between local residents and local government are required for the Coastwise project, in terms of developing community coastal adaptation plans.

To what extent does the conceptual framework represent these emergent barriers, and the complexities in how they manifest and interrelate? At the bottom of the conceptual framework diagram (depicted in white boxes) the framework considers factors affecting social resilience through three different adaptive capacities; 'capacity to prepare', 'recover', and 'adapt'. 'Trust in institutions' is a capacity to adapt factor reviewed in section 3.2.4, alongside 'knowledge' (a 'capacity to prepare' factor). However, the reviewed resilience literature did not discuss the role of knowledge in relation to how information is communicated, and therefore the relationship between trust, information and communication is not represented in the original conceptual framework (Figure 3.6). This can now be explicitly mapped onto the diagram, as Figure 8.4 illustrates. Originally the conceptual framework presented all adaptive capacity factors as equally influential. In light of the empirical results, Figure 8.4 now includes the relationship between trust, information and communication onto the diagram, to highlight the importance of this feedback loop.

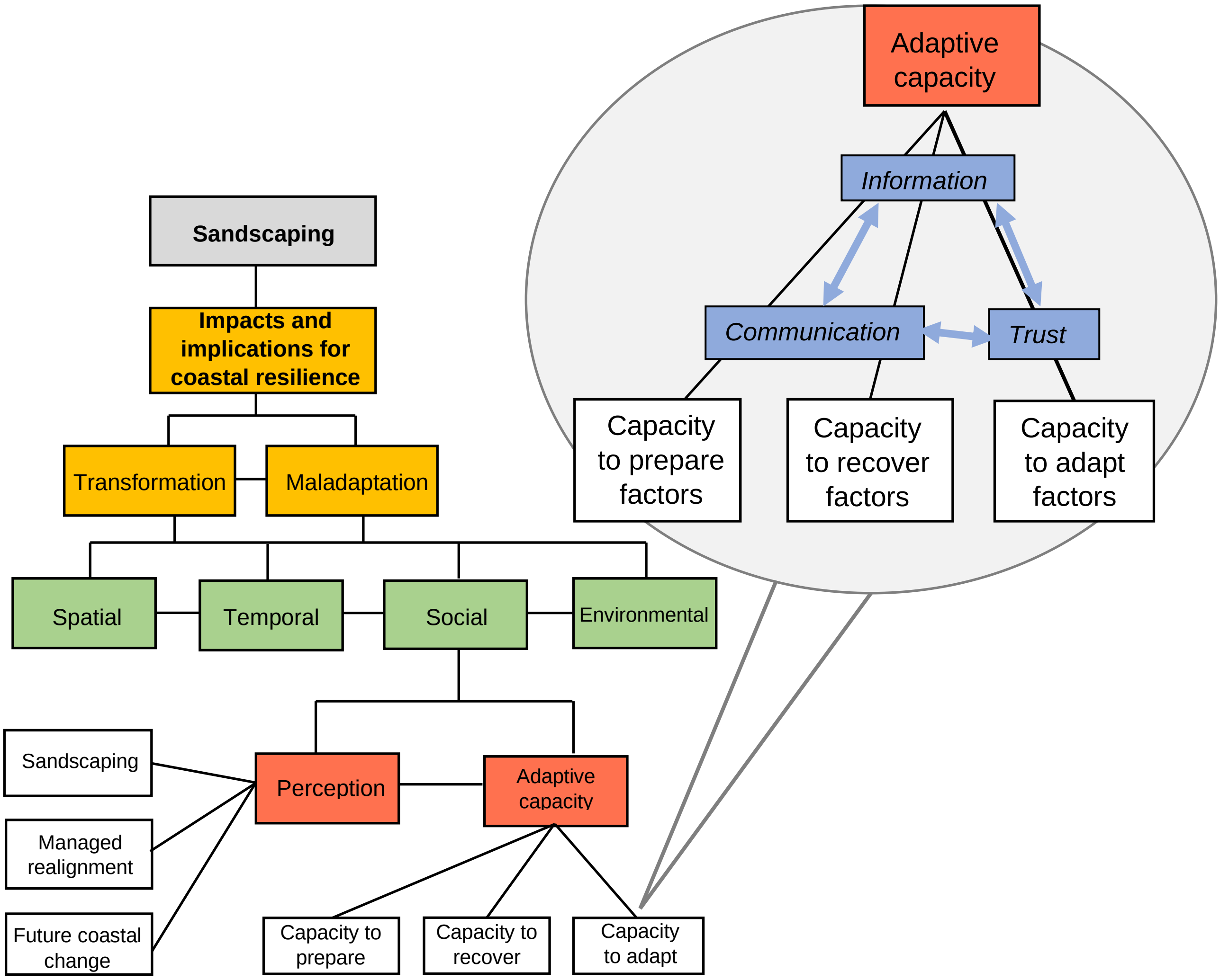


Figure 8.4 The interconnected barriers (depicted as two headed arrows) of perceived or actual lack of information, communication, and trust (inset top right). Proposed modifications are shown in blue. Boxes in yellow refer to resilience, boxes in green refer to scalar elements of environmental justice, and boxes in red refer to perceptions of adapting to coastal change. Boxes in white refer to factors that influence adaptive capacity (bottom of diagram) or different subjects of coastal change (left of diagram).

8.2.6 Key barriers to transformation – lack of policy guidance and funding for coastal adaptation

Two key barriers that appear repeatedly across the empirical chapters include the lack of funding for coastal adaptation (beyond CTAP), and a lack of clear policy guidance to support coastal adaptation at a local level. Local and regional policymaker interviewees explicitly describe this in Chapter 7 as hindering progress in coastal adaptation, describing their role as “*chicken before the egg*” (Regional policymaker interviewee) – difficult to achieve without funding and policy clarity from central government. A tension can therefore be seen at different policy scales (i.e. at different levels of government), and that national level inaction on managing coastal risk is leading to local level inertia. To date, villages such as Happisburgh have experienced one-off projects for coastal adaptation, such as the 2012 Pathfinder Programme, that trial options for how the village can adapt to high erosion risk (e.g. property rollback), but there is no certainty or support beyond the lifetime of an individual project. A national policy on coastal adaptation, with clarity on funding streams and support available to at-risk communities, would ameliorate this.

The arguments posed by participants to the study reflect similar findings in the literature. Gibbs (2016) argues managed realignment has not, and is not, being outlined by central government because it carries the greatest political risk (in terms of being potentially unacceptable to the electorate). Naylor et al., (2019) put forward a similar argument, that longer-term decision-making on adaptation in the UK is compounded by what the authors (ibid) refer to as organisation risk. In other words, political pressure at a local level to maintain defences, which is reiterated by central government after a storm event, in order to maintain the reputation of a local authority. Clarke and Murphy (2023) similarly argue that transformative adaptation to coastal change (adaptation options such as relocation) are compounded by objections in the present-day, which lock-in the risk of maladaptation. This is notwithstanding other policy challenges that policymakers and local residents highlight (see the empirical chapters) as also constraining adaptation efforts on the ground, such as different local authorities and stakeholders having responsibility for different infrastructure on the coast, with different funding streams and planning policies that delay or constrain local action. This amounts to what Hanna et al., (2020, p.1, see Chapter 7) refer to as the "*uncertainty contagion*", where a multitude of barriers of a political dimension inhibits action on coastal realignment.

These findings highlight the link between policy barriers and the risk of maladaptation, which is not currently represented in the conceptual framework diagram. In Figure 8.5, 'Lack of funding' and 'Lack of policy guidance' are now mapped as two key barriers that may lead to increased risk of maladaptation, and hinder transformation (two concepts already present on the diagram). Because of these policy barriers, there is a risk of continual reactive adaptation, such as property rollback after storm events (as has already occurred in Happisburgh, and notably Hemsby in 2023) rather than transformative, proactive adaptation, which policymakers are united (see Chapter 7) in calling for. This national policy vacuum is not solely the case for coastal adaptation, and can be seen in adaptation to other climate risks such as extreme heat, where current infrastructure and societal resilience falls short of long-term adaptation needs (CCC, 2023). A similar trend can be seen internationally, where work by Groen et al., (2022) finds an adaptation gap for coastal risk in the UK and Germany. Across sectors such as health, transport, and infrastructure, UK climate adaptation policy is falling to consider long-term climate risks (CCC, 2023), which is exacerbated by short-term political cycles that reinforce policies of the status quo (Groen et al., 2022). Greater clarity from central government on adaptation policy and funding to alleviate uncertainty of adaptation delivery at a local level is therefore a finding recurrent in multiple climate impacts and countries.

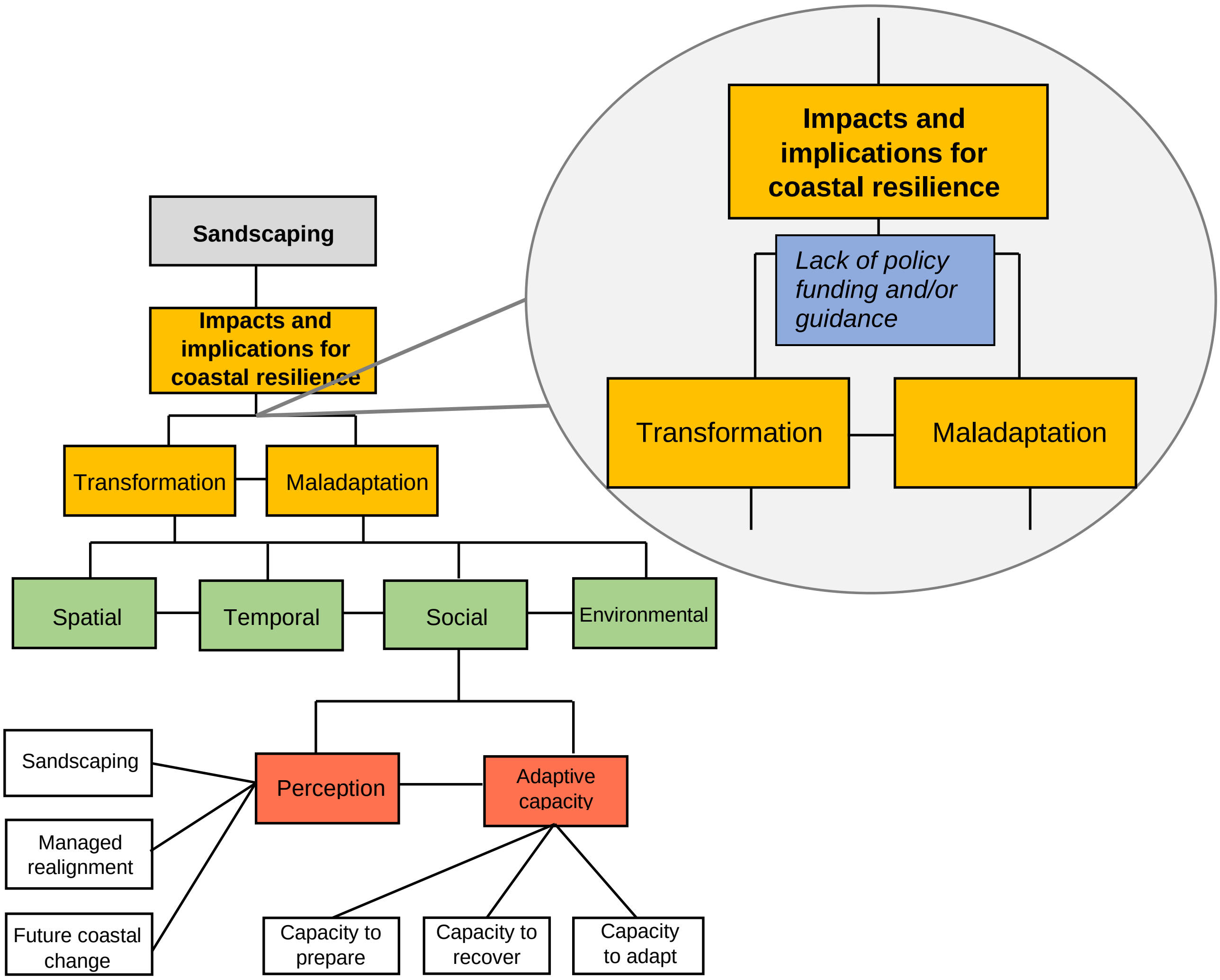


Figure 8.5 Lack of policy funding and/or guidance (blue box shown in inset in top-right corner) are two key barriers that appear as cross-cutting themes across the empirical chapters. These barriers risk perpetuating reactive approaches to coastal adaptation ('maladaptation' box) as opposed to more proactive approaches ('transformation' box). The barriers therefore are important factors in the relationship between the concepts of transformation and maladaptation, in this case study context. Boxes in yellow refer to resilience, boxes in green refer to scalar elements of environmental justice, and boxes in red refer to perceptions of adapting to coastal change. Boxes in white refer to factors that influence adaptive capacity (bottom of diagram) or different subjects of coastal change (left of diagram).

8.2.7 Revised conceptual framework

In summary, the conceptual framework offers an interdisciplinary assessment of understanding changes to coastal resilience bought about by sandscaping, across social and environmental dimensions. It could be applied to other socio-environmental systems where an environmental policy or intervention is being introduced, to understand where and how changes to resilience occurs. The conceptual framework provides a schema to examine the scale-sensitive nature of transformation and resilience, and its links to maladaptation. This section has explored the complexities and scalar tensions that appear across the empirical chapters, using the conceptual framework as an illustration to map these ‘insights’. This includes feedback loops between environmental change and social perceptions, tensions in the range of social views within and across social groups, complexities in the relationship between time and resilience across scales, and the notable barriers of a lack of information, communication, and trust, and a lack of funding or policy guidance. Figure 8.6 brings together all of the proposed modifications to the conceptual framework (shown in blue) that were individually illustrated across Figures 8.1-8.5, drawing upon the empirical insights of the thesis’ case study.

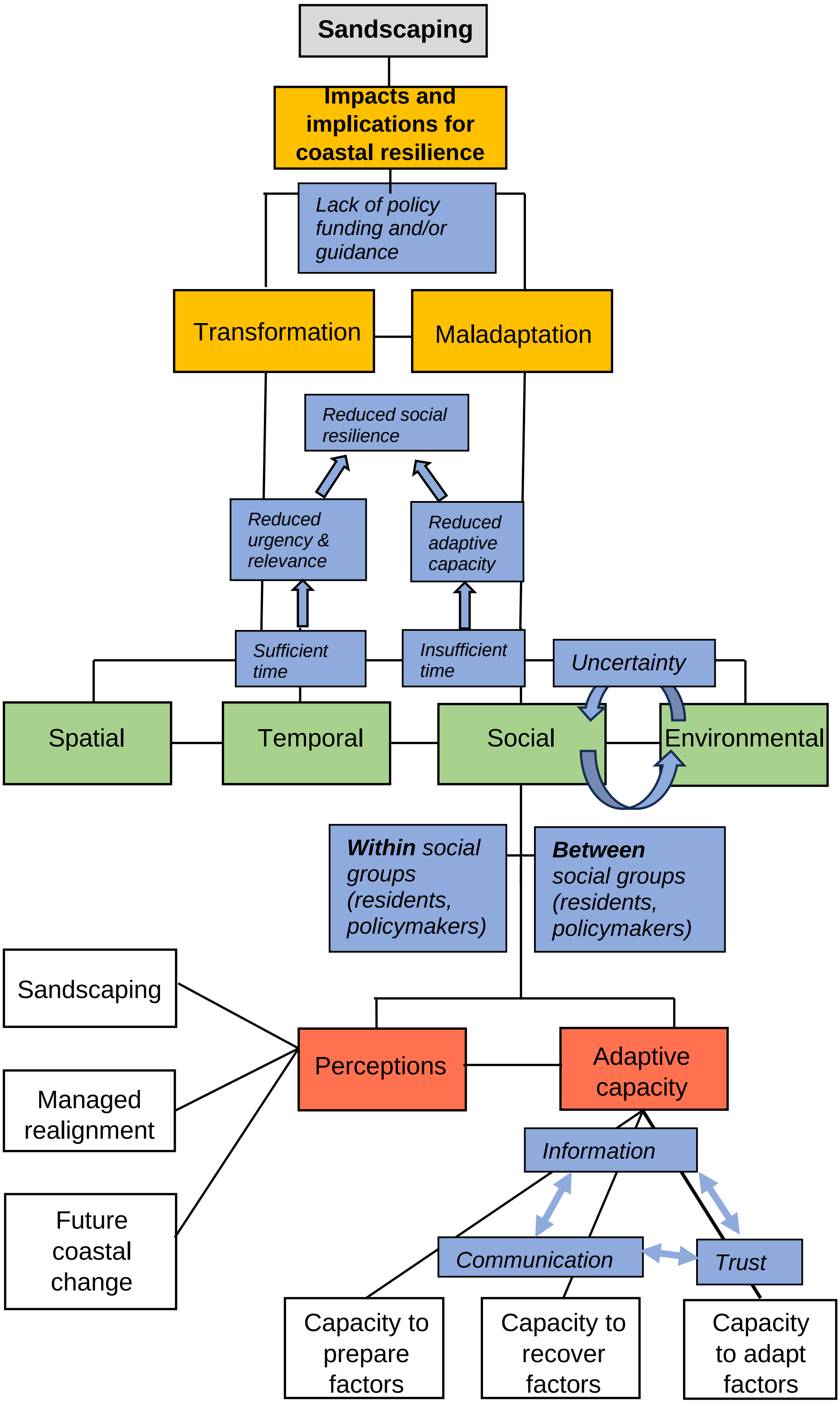


Figure 8.6 Revised conceptual framework (proposed modifications in blue). Boxes in yellow refer to resilience, boxes in green refer to scalar elements of environmental justice, and boxes in red refer to perceptions of adapting to coastal change. Boxes in white refer to factors that influence adaptive capacity (bottom of diagram) or different subjects of coastal change (left of diagram).

8.3 Theoretical contributions of this thesis

This section considers the theoretical contributions of the thesis. Section 8.3.1 discusses findings on the key thesis concepts of transformation, resilience, and maladaptation, and section 8.3.2 explores findings on environmental justice.

8.3.1 Transformation, coastal resilience, and maladaptation

This research utilises the Bacton-Walcott sandscaping scheme as a case study to investigate the impact of a transformative coastal management strategy on coastal resilience. Chapters 5 and 7 highlight the transformative nature of sandscaping in terms of altering geomorphological characteristics of the coast (beach width and volume). As such, the study offers several theoretical findings about the nature of transformation and its associated impact on the resilience of a socio-ecological system. The thesis conceptual framework (section 3.5) presents sandscaping as a transformative intervention that brings a high level of resilience to socio-ecological systems. The theory underpinning this assertion, that transformative strategies are associated with the highest levels of resilience, is discussed in section 3.2.3. As Table 3.1 explores, transformative responses are argued to bring the highest level of resilience because they open up the greatest opportunity for deep-rooted change (Folke et al., 2010, Matyas and Pelling, 2015, Bene and Doyen, 2018; Milhorance et al., 2021). At first glance, the empirical results confirm that sandscaping has been transformative to the coastal system at Bacton and Walcott, in both social and geomorphological dimensions, because the study reveals that beach profile and beach volume are operating in a new equilibrium, Bacton and Walcott residents have not been impacted by coastal storms as they once were, and are learning to live alongside a very different coast. However, these findings on transformation are rooted in empirical results from the period in which the study was undertaken. If the impact of sandscaping on coastal resilience is considered further, on different temporal scales, evidence of transformation is less conclusive.

Firstly, the geomorphological changes brought about by sandscaping are temporary. While academic literature on transformation does not define the length of time with which an intervention in socio-ecological systems can be considered transformative, section 3.2.3 argues there has to be a permanence to such change. Although there is uncertainty on how long sandscaping will last, it is expected to provide protection from coastal storms for up to 20 years. Therefore, the intervention is finite. Secondly, Chapter 7 reveals Bacton and Walcott residents have increased confidence in the future of their village, and a hope that sandscaping will be repeated, which appears to have influenced risk perceptions with regards to future coastal change. If a managed realignment policy after sandscaping is met with increased community apathy to coastal risk, sandscaping may inadvertently be maladaptive. This is because it may introduce additional barriers to preparing for managed realignment for the Bacton-Walcott frontage, which is the longer-term transformative scenario for this part of the coast. Revisiting Maclean et al's (2016) definition of social resilience (section 3.2.1), Chapters 6 and 7 suggest that policymaker interviewees articulate what Maclean et al., (ibid) refer to as "*the adaptive and learning capacity*" (Maclean et al., 2016, p.523) to prepare for future coastal change, but this has not yet transpired amongst the local community, at the time of this research. Therefore, it is the influence of sandscaping on long term coastal adaptation that determines whether it can be considered a transformative coastal management strategy, and one that requires further, longitudinal research on sandscaping towards the end of its 20 year lifetime.

To conclude, the theoretical contribution of this research on transformation, evidenced in the empirical data, is that the relationships between transformation and resilience, and transformation and maladaptation, are highly temporally and spatially scale-sensitive. The conceptual framework explicitly depicts this dependency, as explored above in section 8.2. Sandscaping has temporarily built physical resilience through the addition of placed sediment, but may inadvertently endanger building longer-term social resilience to coastal change by influencing perceptions of coastal risk. Findings also demonstrate the different timescales with which physical and social resilience are built, and therefore the tension, for transformative strategies such as sandscaping, between resilience objectives of a physical nature and a social nature. However, it is important to note that these empirical findings reflect solely the early years of the sandscaping scheme (2019-2022) during which this study was undertaken, and that further work is needed to explore the impact of sandscaping on social resilience across longer timescales (discussed further in 8.5, areas of future work).

This research has also had the opportunity to explore several theoretical debates within literature about resilience. Firstly, it is debated whether greater levels of resilience in a socio-ecological system are concurrent with greater levels of uncertainty (section 3.2.5, Leach, 2008). The empirical results highlight that increased coastal resilience at Bacton and Walcott through sandscaping has also led to increased uncertainty, in terms of how long sandscaping will last and what will succeed the scheme (Chapter 7). Therefore, this study finds a link between increased resilience and increased uncertainty, but this is likely to be context-specific to the nature-based solution in this case study. Secondly, it is debated within literature (section 3.2.3) whether greater levels of resilience in a socio-ecological system also lead to a higher risk of maladaptation. Adaptation measures set with the goal of building resilience can reduce the risk of maladaptation (Leichenko and O'Brien, 2019) because resilient-based policy approaches focus on longer timescales (Eakin et al., 2009). While this study finds a link between a high resilience strategy and added risks of maladaptation, this finding is limited by the timescales of the research. Finally, the research has also provided insights into different capacities of resilience (capacity to prepare, recover and adapt, illustrated in Figure 3.3, section 3.2.4) and the extent to which current policy rhetoric on coastal adaptation to managed realignment (Chapters 6 and 7) focuses on these different aspects of social resilience.

8.3.2 Environmental justice

Theoretical insights on environmental justice

The theoretical insights discussed in 8.3.1 above, namely that the relationship between transformation, resilience and maladaptation is highly scale-sensitive, also bring relevant findings to understandings of distributional justice and the environmental justice field. The literature on distributional justice (section 3.3.4 of the literature review) typically frames subjects of environmental harms as either 'winners' or 'losers', but this thesis adds to work in the environmental justice field, by highlighting that there are many trade-offs in the introduction of a novel nature-based solution that make such a purely binary assessment of distributional impacts less relevant. For example, a binary framing works on a cursory level, that there are villages protected (Bacton and Walcott) and unprotected (Happisburgh) by coastal defences. But on closer inspection, Chapter 5 also reveals that Bacton and Walcott residents report mixed (i.e. positive and negative) impacts at a variety of levels from the sandscaping scheme. Furthermore, Chapter 7 highlights that although Bacton and Walcott residents are protected in the present day by sandscaping, the scheme is temporary. Bacton and Walcott residents may therefore be at coastal risk in the future, as Happisburgh residents are in the present day (Chapter 6). Therefore, applications of environmental justice – especially distributional justice - in a coastal management context, particularly regarding the introduction and implementation of novel nature-based solutions, requires further nuance than a binary classification of benefits and harms and whom they befall. This research shows that temporal and spatial aspects affect such considerations, as well as the values and features of places and people's connection with these.

This research also highlights the need for a plurality of justice perspectives in coastal decision-making, and a recognition that environmental justice principles for coastal management can be built from different philosophical foundations. This study predominantly focuses on egalitarian principles of justice, by investigating where the impacts and perspectives of sandscaping and managed realignment are different amongst local communities. However it also considers a capabilities approach to justice, (in other words, a valued life as defined by participants (Sen, 2009)). A focus on egalitarianism in this research is adopted because current coastal management policy uses a utilitarian logic in determining SMP policy for coastal areas (that therefore lends itself to be explored with an egalitarian framing). However, other theories of justice such as the capabilities approach would also be relevant for coastal management policy, that considers what individuals perceive as of value in living and working in coastal areas. The way in which different justice perspectives can be applied to support a specific point of view is particularly evident in Chapter 6, where arguments using utilitarian, egalitarian and a capabilities framing are all made by residents within and across different villages, and by policymakers. This creates opposing arguments by different stakeholders, for example in Chapter 6 where points are made on coastal funding from a national, local, and non-economic perspective. It is therefore necessary for any application of environmental justice principles to coastal policy to be mindful of these different justice perspectives. In particular, Chapter 6 highlights why coastal policy pursued through a utilitarian logic alone raises several egalitarian justice issues in the way coastal impacts are experienced across coastal communities.

The value of an environmental justice lens in the research

This thesis adopts an environmental justice lens to examine the impacts of sandscaping, and where resilience is built within the coastal system, across different scales. While the distribution of the impacts of sandscaping and wider coastal change could have been explored without an environmental justice lens, environmental justice was crucial in this research project to explore other justice elements, not just relating to distribution, which are also pertinent. For example, Chapter 6 highlights there are multiple forms of value of a coastal environment to the community of Happisburgh, such as the restorative benefits and unique coastal heritage of the coastal frontage. Presently, these non-monetary forms of value are not accounted for in coastal decision-making. This is a recognitional injustice that could otherwise have been omitted from the analysis of this study if an environmental justice framing had not been adopted.

Furthermore, Chapter 7 reveals the material value of Bacton Gas Terminal at a national level, supplying a third of the UK's gas supply, is expected by policymakers to be the crucial factor in deciding the future management approach at Bacton and Walcott. This could potentially interact with current policies, and affect policy aspirations at a local level to enable opportunities towards managed realignment sooner. An environmental justice lens, examining issues of recognitional justice, therefore allowed the research to explore 'who' (which actors) is driving coastal management policy, for this particular stretch of coast, and why this novel nature-based solution was introduced.

In addition, the use of an environmental justice lens was particularly relevant for exploring coastal adaptation during the time of the study, and in the democratic context in the UK, given that Coastwise, and coastal adaptation policy narrative at a national level, is increasingly promoting civic participation. All three empirical chapters raise questions of participatory justice in the level of trust, information, and willingness of coastal residents to engage in conversations around adaptation they have historically perceived as overlooking local concerns (and relations with policymakers). For example, Chapter 6 demonstrates that implementation of the principles of participatory justice (the degree to which local residents can meaningfully contribute to local decision-making on coastal management) and of recognition (the degree to which local residents can frame the future narrative of their settlement) are pivotal to the shaping and evolution of coastal management strategies and trust in coastal governance. An environmental justice lens therefore allowed the research to examine pertinent barriers for coastal adaptation policy and civic engagement in the deployment of nature-based solutions going forwards.

There are several implications, however, to the environmental justice issues that this thesis identifies across Chapters 5-7. Firstly, what can practitioners and local policymakers do to alleviate these aforementioned issues and enable more transparent and inclusive engagement? Chapter 6 highlights there are limits to co-creation of adaptation plans amongst residents and policymakers, if strong preferences, such as coastal defences, will not be an option ‘on the table’ to start off with. Similarly, the sandscaping scheme was implemented in spite of some objections by local residents. These are complex challenges with no straight-forward answers. Nonetheless, this thesis can point to a set of justice actions in coastal management, which are summarised in Table 8.1. These are drawn from the justice issues reported across Chapters 5-7. By adhering to the justice actions in Table 8.1, local policymakers and coastal practitioners can enable transparent and inclusive engagement, and use co-production to work through the boundaries of co-creation (in other words, 'red lines' such as no further coastal defences). This will require time and opportunities for communities to meaningfully engage, so that an alternative future has local support. Table 8.1 can also be used as a guide to be reinterpreted by practitioners working in other at-risk settlements, to understand the starting point for communities to engaging on coastal adaptation issues.

Table 8.1 Justice actions in adapting to coastal change, summarising insights from Chapters 5-7. Table 8.1 extends the analysis of environmental justice issues identified in Chapters 5-7 to identify the key aspects of an environmentally just approach to coastal management for at-risk areas.

Dimension of environmental justice	**Actions for coastal management**
Distributional justice	There is adequate practical and financial support for residents facing property or asset loss due to flooding / erosion.
	There is wider provision of mental health support when facing flood or erosion impacts. This could be as standard (for example during coastal management consultations).
	Wellbeing – 'thriving communities' – is a central objective of coastal adaptation.
Participatory justice	Wide-reaching, sustained community engagement, with adept facilitators supported by adequate resources, to identify and accommodate differences of opinion within communities on practical dimensions of rollback, and to build trust.
	There is regular information and communication of coastal policy provided to communities in accessible, non-technical language. This reaches all members within a community, rather than representative groups.
	A community and local policymaker group is set-up to regularly discuss coastal management issues.
Recognitional justice	There is a counteracting, positive vision for the future of a settlement, that overcomes the impacts of sense of loss and place attachment.
	Pace of coastal change does not threaten the integrity, viability, or cultural heritage of a settlement.
	Community group is recognised by wider public and media as the legitimate voice

	(‘spokesperson’) on future of settlement. The group regularly publish information and set the narrative of the future of their settlement.

The viability of combining environmental justice with resilience and adaptation

A research gap identified in the literature review (section 3.4.1) is the growing use of hybridised concepts such as ‘just adaptation’ and ‘just resilience’ (for example in EEA working/technical papers (Breil et al., 2021; Lager et al., 2023)), without a discussion on the compatibility of such concepts. This is in spite of longstanding criticisms of resilience as a concept, for example, that it fails to consider social trade-offs and issues of power and equity (section 3.2.6). This research has considered the compatibility and crossover between components from literatures on resilience, environmental justice and adaptation, which are reflected in the conceptual framework of this thesis. This provides an opportunity to also examine these literatures with regards to transformation and maladaptation. While transformation and maladaptation have distinct literatures and are not always examined together, some studies have brought the concepts (and respective literatures) together (for example Clarke and Murphy, 2023).

The empirical findings of this research demonstrate several fundamental differences between resilience and environmental justice, that make hybridisation challenging (i.e. to achieve the objectives of both resilience and justice as defined in sections 3.2.1 and 3.3.1, respectively). In this case study, the two concepts can be seen to prioritise different objectives: through a resilience lens, the aim of sandscaping is to have geomorphological capacity to withstand coastal storms (Chapter 5). In contrast, a justice perspective is principally aimed at alleviating environmental harms on social groups (Chapter 6). The two concepts therefore have very different units of analysis; a more focused look at certain social groups (environmental justice) versus the entire socio-ecological system (resilience). This research also shows that considerations of resilience and environmental justice operate on different timeframes. The justice issues of coastal management raised by local residents in Chapter 6 are situated in the present-day period of the study, and past lived experience, where implications for coastal resilience, explored in Chapter 7, emerge mainly in relation to future timescales. Interviewees applied different ways of thinking about coastal management to different timescales, depending on when impacts were perceived to occur. Lastly, the two concepts are rooted in different epistemological positions. Although later work on resilience has applied it to social systems, resilience (section 3.2.1) originates from the disciplines of ecology and engineering, whereas environmental justice (section 3.3.1) is rooted in social science epistemologies.

Despite these findings, which concur with academic literature that resilience and environmental justice have different framings, focuses and epistemological roots (Eakin et al., 2009), the empirical results of this thesis nevertheless also highlight the merit of a hybridised 'just resilience' approach to coastal policy (as similarly argued by Doorn et al., 2019). A principal finding from this research is that incorporating justice principles into a 'just resilience' framing overcomes some of the limitations of resilience, because a justice focus serves to illuminate scale-sensitive trade-offs among components of a system that the latter does not consider (given its emphasis on a systems perspective). An example of this is where the environmental justice lens of the research has demonstrated how residents are differently impacted and perceive environmental change in different ways (Chapter 5 with regards to sandscaping, Chapter 6 with regards to coastal change at Happisburgh). However, the adopted definition of social resilience in this study (Maclean et al., 2016; section 3.2.1) does not acknowledge potentially differential impacts beyond observable change at the system level. Therefore, incorporating environmental justice principles into the concept of resilience can help identify where changes to resilience occur at different scales, and therefore can add further nuance to Maclean et al's (ibid) conceptualisation of social resilience.

Secondly, an integral area where justice and resilience principles align, in a coastal management context, can be seen with regards to anticipatory adaptation. The empirical chapters indicate that anticipatory rather than reactive coastal adaptation may address perceived injustices and build higher levels of resilience in a socio-ecological system. For example, Chapter 6 highlights it is a question of procedural justice that managed realignment is proactively planned, because it allows time to facilitate adaptation that is developed and recognised by the communities themselves, through an engagement process that is deemed meaningful and fair. Similarly, Chapters 6 and 7 find that time is needed to build community adaptive capacity for coastal change, particularly with regards to 'capacity to adapt' factors such as building trust in policymakers, overcoming barriers associated with place attachment, or accommodating wide differences of opinion within a community. Bacton and Walcott residents (Chapter 7) have greater time to prepare for adaptation options associated with a managed realignment policy, than Happisburgh residents (Chapter 6), due to the existence of the sandscaping scheme. This study therefore supports research from the resilience literature (section 3.2.3) that deliberate (i.e., anticipatory) transformation is more resilient than forced (i.e. reactive) transformation responses, and that it is particularly relevant to combine the resilience and justice literatures in contexts where anticipatory adaptation and the avoidance of maladaptation are key objectives.

Lastly, a hybridised 'just resilience' concept also strengthens the conceptualisation of resilience, because it contributes to making the risk of maladaptation more explicit. Chapters 5 and 7 highlight that sandscaping is physically transformative but may enhance the risk of maladaptation through its effect on people's perceptions of managing future coastal change. Meanwhile Chapter 6 highlights low acceptance of adaptation options for managed realignment where present and past coastal policy is perceived to be unjust. The definition of social resilience in this research (Maclean et al., 2016, p.523; section 3.2.1) does not mention the risk of maladaptation, solely stating the objective as to "*maintain system function*". But the empirical results highlight that 'undesirable change' (as is often used to describe maladaptation, see section 3.2.3) in a coastal context means different things to different people, and transformative interventions such as sandscaping and managed realignment will cause differential environmental 'harms'. Therefore, the resilience literature on transformation could be more explicit about the risk of maladaptation, and an environmental justice lens is found in this research to bring this contribution, which a resilience framing may overlook.

8.4 Thesis methodological contributions

This research demonstrates the value of an interdisciplinary investigation of coastal resilience, which highlights the close connection between geomorphological change and social perceptions, and differences in the timing and scale of building physical and social resilience. In contrast, despite longstanding and wide-ranging research on the concept of resilience, including a more recent proliferation of resilience studies in the social sciences, the resilience literature is typically associated with a particular discipline, with notable exceptions (for example Adger, 2000; Doorn et al., 2019; Nightingale et al., 2021). This study therefore furthers the resilience field by providing a broader perspective on resilience that bridges geomorphological and social science literature, going beyond the social sciences to include a geomorphological study of the coast. Secondly, as argued in Chapter 4, the methodological approach to the research, in terms of being both *interdisciplinary* and *iterative* in the sequential nature of research instruments, allows insights between the geomorphological analysis and social data to 'cross-pollinate' and influence the focus and future direction of the study. This allows for a deeper understanding of the dynamics within the case study area, and an opportunity to further explore emerging insights.

This thesis, therefore, provides an interdisciplinary assessment of the effectiveness of sandscaping in Chapter 5, that draws upon social perspectives as well as examining geomorphological performance. This is a novel contribution to the mega-nourishment literature and a broadening of scope of evaluating mega-nourishment schemes: research to date on the Bacton-Walcott sandscaping scheme, and the Zandmotor scheme in the Netherlands, have either applied exclusively quantitative methods to focus on ecological or geomorphological impacts (for example De Schipper et al., 2016; Hoonhout and de Vries, 2017; Luijendijk et al., 2017; Post, 2019; Pit et al., 2020; Roest et al., 2021), or separately examined specific social impacts such as recreational changes to using the coast (Taal et al., 2016; Huisman et al., 2021), implications for coastal governance (Bontje and Slinger, 2017; Vikolainen et al., 2017), or the added social value of implementing mega-nourishment schemes (Day et al., 2023; Vreugdenhil and Slinger, 2023), that are primarily qualitative studies (see also section 2.3.2). Therefore, this thesis is the first mixed-methods research to date on sandscaping that combines both qualitative and quantitative approaches, within a single study, to investigate the impacts of mega-nourishment across multiple dimensions (social and geomorphological). Figure 8.7 illustrates this methodological contribution to the research. Using sandscaping as a case study has provided broader insights on how we can devise evaluations of mega-nourishments schemes (or indeed more broadly, such as nature-based solutions), for a more holistic assessment of their effectiveness, and ultimately broader outcomes. In other words, effectiveness of coastal nature-based solutions should not just focus on how it reduces flood and erosion risk over time (left-hand box in Figure 8.7) but how unintended social impacts and misunderstandings about the strategy can be avoided, alongside how positive social impacts can be maximised (right-hand box in Figure 8.7).

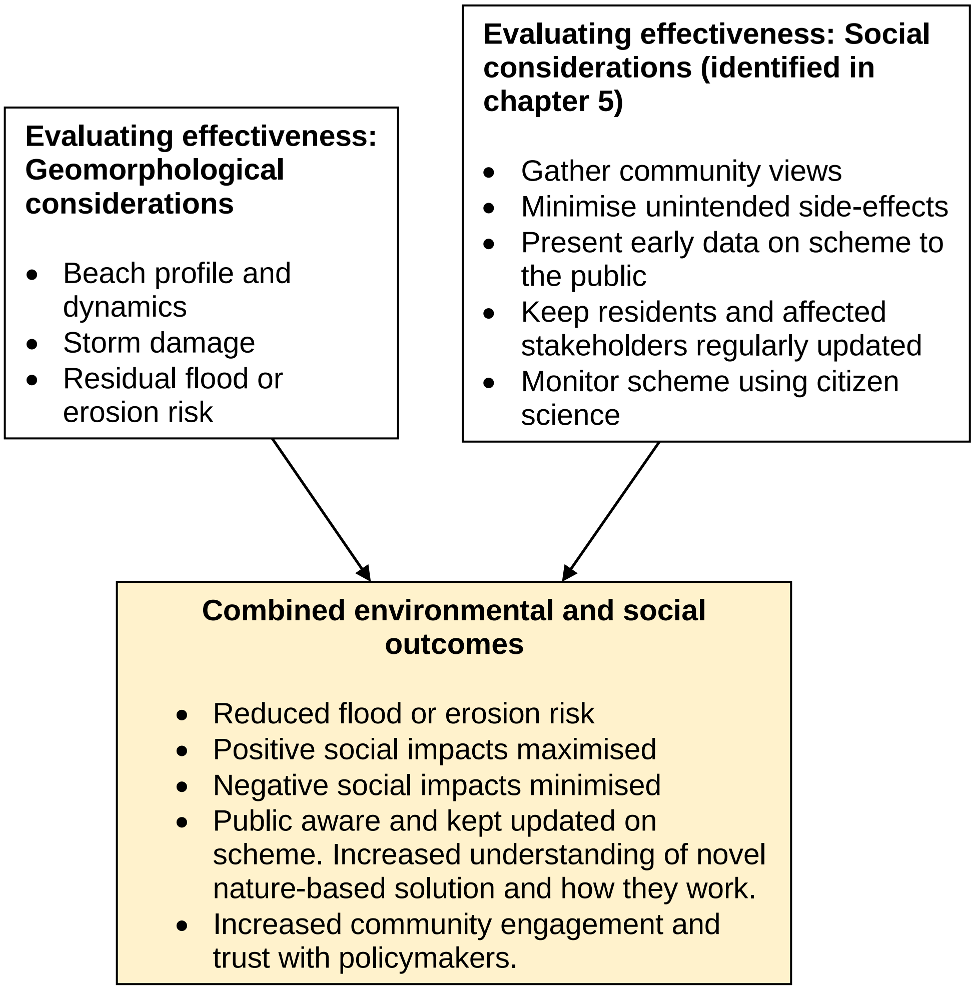


Figure 8.7 Expanded scope for evaluating the effectiveness of mega-nourishment, based on findings from this thesis. This is a significant finding, because it allows negative social impacts and misunderstandings about future schemes to be avoided, alongside how positive social impacts can be maximised.

8.5 Limitations and areas of further research

The final section of this discussion and synthesis chapter considers limitations of the research in this thesis and areas of future research. It builds on, but also goes beyond the purely methodological focus of limitations to the research already outlined in section 4.5.2, which included a review of the impact of the Covid-19 pandemic on the research.

8.5.1 Social impacts of sandscaping and coastal resilience

The most significant limitation, as highlighted already in this chapter, is that the research can only observe the impacts of sandscaping for a snapshot in time (during a 3.5 year PhD). Consequently, this thesis can only make an assessment on impacts to coastal resilience in the first four years of the sandscaping scheme (2019-2022). This is sufficient time to study direct geomorphological changes brought about by sandscaping, but implications to social resilience may unfold much later over the scheme's 15-20 year lifespan. The empirical findings demonstrate initial implications of sandscaping on reduced perceived relevance of long-term coastal risk, but this could change as the scheme evolves, as energy policy surrounding Bacton Gas Terminal develops, and community engagement on coastal adaptation continues, through CTAP or otherwise.

It would therefore be relevant to undertake further in-depth qualitative work in the later stages of sandscaping's lifetime, or longitudinal work throughout the lifetime of the scheme, to explore how Bacton and Walcott residents perceive and experience the sandscaping scheme, and coastal change post-sandscaping, over time. This would provide additional insights on social resilience, and links between transformation and maladaptation, over the full lifetime of the scheme. In 2023, The Crown Estate commissioned a study on the added value of the sandscaping scheme, in terms of wider socioeconomic benefits, (Day et al., 2023), but to date there has been no further research on how local resident perceptions of coastal change at Bacton and Walcott are evolving over time. Whilst ACM LiDAR data for the Norfolk coast are available from 2011, no such comparable social 'baseline' of data exists, which limits the extent to which conclusions could be drawn on how social resilience to coastal change has been impacted by sandscaping. A future study or longitudinal work, following on from this research, would provide a more direct complement.

8.5.2 LiDAR availability and data extent

Limitations to the use of LiDAR data mainly relate to the methodological scope achievable from the LiDAR data available, and were initially outlined in section 4.5.2 but are returned to here in light of the empirical results. The secondary LiDAR data provided by RH offers a crucial snapshot of elevation changes below the foreshore, and extends to a greater depth (approximately -15m below sea level) than the LiDAR data available from the ACM programme. However, the data series from RH began after sandscaping was completed, in contrast to the ACM programme. Consequently, while Chapter 5 illustrates important changes in sediment in the lower sub-tidal zone with RH data, this trend can only be observed from the beginning of the sandscaping scheme. A beach profile to the depths of the lower sub-tidal before 2019 would have been advantageous as a comparison, to further identify the extent of geomorphological changes.

Secondly, the ACM LiDAR data series is annual, and the data is collected at different times of the year. While this was not found to significantly affect the findings in this study (although there is monthly variation in the date of the LiDAR campaigns, they are all conducted within a winter season and therefore all share a winter beach profile), some of the differences between years in Chapters 5 and 7 is possibly partly due to date of data collection. For example, data collection in some years may have occurred soon after a depositional or erosional event, which could explain some of the variation between years, i.e. there is natural variation in the beach not caused by sandscaping. An expansion to the LiDAR data sets, such as biannual or quarterly LiDAR campaigns for the ACM data, would offer an opportunity for further research to examine seasonal geomorphological changes due to sandscaping, that were not possible to explore with the existing annual data series. Similarly to the qualitative findings of this thesis, continued analysis of the geomorphological impact of sandscaping would be useful. Furthermore, direct investigation of sediment movement (e.g. using sediment tracers), which was outside the scope of this study, would provide insight on where placed sediment is migrating to.

8.5.3 Sequential research methodology, and timing of policy developments

An iterative research design, where research instruments follow in succession of one other and inform the next step of the work, crucially has allowed findings of each stage of the research process to feed into the design of successive steps of the research. A challenge to this approach is comparing social perceptions across time, where one year elapsed between conducting the survey and conducting the policymaker interviews. This is particularly relevant in this case study context, where policy developments of CTAP emerged in 2022, after the survey data. To address this, the thesis is sensitive to these differences in timing when drawing conclusions between different perspectives in the resident survey and interview data. Ultimately, any data collection will always be reflecting a particular snapshot in time. Future research could explore undertaking social research methods at the same time, if researcher capacity allows.

8.5.4 Additional areas of future research

Finally, the empirical chapters identify specific areas of further research. This includes exploring the format, style, tone, and content for effective public communications on the deployment of innovative nature-based solutions such as sandscaping. Future research could investigate key questions raised from this study's empirical research; why different types of information, and forms of communication, are trusted or not, and how and why information is interpreted differently. Secondly, the empirical chapters highlight that sense of loss and eco-anxiety could be relevant to explore in a separate, specific in-depth study (i.e. longitudinal or qualitative work), particularly regarding their role as potential barriers to the development of community adaptation plans. This would provide insight into how challenges relating to sense of loss and eco-anxiety specifically can be addressed in community engagement on coastal issues, so that future public engagement can be best designed to support communities and overcome such challenges. Lastly, a further research study could compare this study's findings with other sandscaping sites across the UK or other countries. This would identify cross-cutting or context specific impacts of the use of sandscaping in coastal management.

8.6 Concluding remarks to chapter

This chapter has explored the contributions of the thesis, by returning to the research questions and conceptual framework. This research finds that sandscaping is physically transformative, but there is a risk of maladaptation on longer timescales if the intervention contributes to reduced prioritisation and perceived relevance of the risk of coastal change, for local residents. It demonstrates the value to incorporating environmental justice into adaptation policy focussed on building resilience, where a justice lens highlights the scale-sensitive nature of when, where and why resilience is built, makes explicit the risks of maladaptation, and where a perceived just coastal policy may enhance community willingness to adapt to coastal change and acceptance of adaptation strategies. As more and more coastal settlements this century are at risk of losing ‘hold the line’ status and will require adapting to managed realignment, this thesis provides relevant learning on how a just approach to building resilience to future coastal change can be facilitated. The next and final chapter of the thesis provides a short concluding summary of the key findings of the study by research question, and a summary of the key empirical insights. These are also summarised in a short section for policymakers, practitioners, academics, and other key stakeholders working in a coastal management or adaptation context in the UK or internationally.

Chapter 9. Conclusions

9.1 Introduction

This conclusions chapter builds on from the discussion of cross-cutting themes and the theoretical and methodological contributions of the thesis explored in Chapter 8, by providing a short summary of the key conclusions of the research in light of the research questions (section 9.2). Section 9.2.1 reflects on how sandscaping has transformed the physical resilience of the coastal system (research question 1), section 9.2.2 brings together the findings on residents perceptions and experiences of coastal change (research question 2), and section 9.2.3 considers implications for incorporating environmental justice into coastal adaptation policy that focuses on building resilience (research question 3). Secondly, a concluding summary of policy-orientated empirical findings is provided in section 9.3. In addition to this standalone conclusions chapter, a short summary of the research has been produced for local residents interviewed in the study (Appendix 8), and coastal policymakers (Appendix 9).

9.2 Conclusions by research question

9.2.1 Research question 1. Has sandscaping transformed the physical resilience of the coastal system? (Is the scheme working as expected, and what are the observed coastal changes in the first four years)?

Findings for research question 1 cut across the empirical chapters which examined changes to beach profile (Chapter 5), cliff rate of retreat (Chapter 6), and beach sediment volumes (Chapter 7). From 2019 to 2022 (the first three and a half years of the sandscaping scheme), beach profile and beach sediment budgets have changed dramatically at Bacton and Walcott (RQ1a). Analysis in Chapter 5 revealed the width of the upper (dry) part of Bacton and Walcott beach increased by approximately 50m in 2019 (when sandscaping was implemented), as the foreshore had extended by approximately 50m offshore (Figure 5.1). The village beaches were initially several metres higher in 2019 than pre-sandscaping levels (2018), and although elevation of the upper beach generally saw a decline from 2019 onwards, elevation in 2022 still remains above pre-sandscaping levels. Furthermore, 2022 saw significant amounts of sediment returning (particularly at Bacton), with an increase in sediment on the upper beach compared to 2021. This demonstrates the dynamic nature of the sandscaping scheme.

The extent of the initial placed sediment, causing these changes in beach profile from 2019 onwards, is demonstrated in the beach volume calculations in Chapter 7. The village frontages saw a 50% (Bacton) and 77% (Walcott) increase in sediment in 2019 compared to 2018. Answering research question 1c (section 7.4.2), beach volume was found to be significantly greater after sandscaping (at a 95% confidence interval) at the terminal ($p=0.007$), the village of Bacton ($p<0.001$) and the village of Walcott ($p=0.004$), when comparing the four years before (2015-2018) to after sandscaping (2019-2022). By comparison, beach volume at Happisburgh North ($p=0.57$) and Happisburgh South ($p=0.89$) is not significantly different (at a 95% confidence interval), when comparing the years before (2015-2018) and after (2019-2022) sandscaping. This suggests that whilst changes in beach volume cannot only be attributed to sandscaping, the significant difference in response of beaches protected by the scheme (Bacton Gas Terminal, Bacton and Walcott) compared to Happisburgh, suggests that sandscaping was a dominant factor in determining beach volume. Moreover, average annual cliff retreat (between 2015-2022) at Happisburgh North (1.9m yr^{-1}, +/- 1.4m) and Happisburgh South (1.1m yr^{-1}, +/-1.0m) (Chapter 6) exceeds historical averages (approximately 0.4m yr^{-1}, 1907-1950) (Dickson et al., 2007), highlighting the vulnerability of this village to coastal change. Cliff retreat maps in Chapter 6 show the considerable variation and localised extent of coastal retreat at Happisburgh, of significance to local residents (and linking to research question 2) in terms of uncertainty in where and by how much the local coast is changing.

The dramatic changes in beach profile and beach volume at Bacton and Walcott can be observed in the Winter 2019 LiDAR data. This indicates that the geomorphological changes occurred rapidly (i.e., within the first few months of the scheme), and therefore, that physical resilience has been built near instantaneously as a result of sandscaping. It is important to note however, that changes to beach profile and beach volume through addition of sediment are temporary, as placed sediment will gradually migrate. As outlined in Chapter 2, additional sediment through sandscaping provides a buffer during storm events and reduces the likelihood of scour at the base of cliffs or sea defences. Because of increases in beach height and width at Bacton and Walcott, waves are breaking further offshore than pre-sandscaping, also reducing the risk of overtopping existing sea defences. Whilst the analysis in Chapters 5 and 7 reveal that beach elevation and beach volume are fluctuating year to year, the observed decrease in beach volume in the first few years of the scheme was not the same order of magnitude as the addition of placed sediment in 2019, i.e. a significant amount of the placed sediment remained in the immediate beach system. Furthermore, the slight increase, particularly at Bacton, in the amount of sediment on the upper (dry) beach in 2022, was observed alongside an overall trend from 2019-2022 of increased sediment in the lower subtidal zone (Figure 5.1). Crucially, the engineers of the scheme (RH, 2020; 2022a) argue the presence of sediment in the lower subtidal zone is still having a buffering effect against coastal storms, by impacting wave attenuation. It is likely that the sediment increase observable at this depth is from migrated placed sediment, but confirming this is outside the scope of this study. It does, however, suggest that placed sediment is remaining within the coastal system, and analysis by RH (2022a) demonstrates that sediment has not being lost offshore in significant quantities in the first few years of the scheme.

In conclusion, sandscaping has rapidly built physical resilience into the coastal system at Bacton and Walcott, in terms of dramatically increased beach width and beach volume from 2019-2022. The modelled expectations of the scheme (detailed in section 2.4.3) were for the nourished beaches to gradually lose sediment, and see sediment migrate cross-shore and alongshore, over time. Overall, the beach profile (Chapter 5) and beach volume (Chapter 7) estimations concur that the sandscaping scheme is working as expected in the first few years of the scheme, given the movement of sediment observable in this research's geomorphological analysis matches modelled expectations of the scheme. As waves are now breaking further offshore (Chapter 5), and beach volume has significantly increased across the protected area (Chapter 7), it is evident that sandscaping has improved physical resilience to coastal change within the timeframe studied, as was intended.

9.2.2 Research question 2. What are resident perceptions and experiences of coastal change, and how do these compare to coastal policymakers, and between villages of differing proximity to sandscaping, and differing SMP designations?

This research question qualitatively focuses on views and the lived experience of coastal change in the case study area, through three sub-questions, and the three empirical chapters (5-7) each focus on one sub-question:

RQ2a. What are the social impacts and perceptions of sandscaping among Bacton and Walcott residents? (Chapter 5)

Chapter 5 reveals that sandscaping has brought wider socioeconomic benefits for Bacton and Walcott residents than solely coastal protection, although a uniquely positive experience is not reported by all. Increased tourism, trade, recreational opportunities and property prices, alongside reduced anxiety about coastal storms and the future, were the main reported benefits. There are strong differences of opinion on the scheme and how effective it is to protect from flooding and erosion, drawing upon different observations of the first few years of sandscaping, that likely reflect deeply held views, values, and levels of trust in local coastal management. A sizeable number of residents surveyed and interviewed expressed concern about the recent drop in placed sand on Bacton and Walcott beaches, and there is more widespread doubt that the scheme will last 20 years (even amongst residents that are very satisfied with the scheme). There is some degree of scepticism of sandscaping as a coastal management strategy, which likely reflects that it is novel (in contrast to hard defences), and consequently, local residents near unanimously expressed a desire for more information about sandscaping and whether the scheme is performing as expected.

RQ2b. For Happisburgh residents, what are the perceptions and lived experiences of past, present, and future coastal change? (Chapter 6)

Chapter 6 highlights the numerous practical, financial and emotional impacts for Happisburgh residents living alongside an unprotected, eroding coastline, illuminated in the chapter as different types of environmental justice 'harms' (distribution, procedural, recognition). Residents describe the impact of blight, low property prices, and anxiety for the future of the village, and dismay of a coastal management approach, outlined by policymaker interviewees, that rules out further coastal defences or property compensation. The wide differences of opinion within the community, some strongly felt, on the use of coastal defences and the repurposing of at-risk land within the village, alongside prevailing distrust in how coastal risk has historically been managed, represent key barriers to CTAP and building a community consensus for coastal adaptation plans that coastal policymakers are now focussed on. There is concern amongst local residents that the rate of coastal erosion is progressing at a pace too fast to adapt to coastal change in a just manner, that protects the identity and future viability of the village.

RQ2c. For Bacton and Walcott residents, how do perceptions of sandscaping affect willingness to adapt and perceptions of coastal change beyond the lifetime of the scheme? (Chapter 7)

Lastly, Chapter 7 indicates that Bacton and Walcott residents have a sense of security and increased confidence that their frontage will remain protected post-sandscaping, because of the perceived importance of Bacton Gas Terminal. At the time of the research, there was media speculation that Bacton Gas Terminal would repurpose as a site for renewable energy, which residents interpret as a sign that sandscaping may be repeated in the future. There is currently little evidence amongst local residents of perceived urgency or relevance of the need to prepare for coastal change after sandscaping has gone, in strong contrast to the perspectives of coastal policymaker interviewees. This suggests there is a risk that the implementation of sandscaping could inadvertently decrease perceptions of risks about coastal change on longer timescales (i.e. in 20 years' time). For many residents, the perceived return of risks associated with coastal change are now at a point beyond their lifetime. This is despite a strong desire from coastal policymakers to initiate discussions with local residents about managed realignment and future adaptation. It suggests that the future of sandscaping and Bacton Gas Terminal could distract from longer-term coastal adaptation planning for the villages.

9.2.3 Research question 3. What are the implications of the above findings on incorporating environmental justice into coastal adaptation policy that focuses on building resilience?

This section summarises the key findings explored in depth in section 8.3.2. The findings from the empirical chapters demonstrate the value of an environmental justice perspective in coastal management. Firstly, an environmental justice lens draws attention to, and makes explicit, trade-offs in coastal decision-making. For example, the variety of perspectives on perceived injustices at different temporal and scalar levels, such as which locations receive coastal protection, shown in Chapter 6 by the disproportionate impacts Happisburgh residents' experience compared to Bacton and Walcott residents (at this current time), or trade-offs in national and local interests, shown in Chapter 7 by tensions in what is prioritised regarding the future of Bacton Gas Terminal. These trade-offs are not necessarily apparent from a coastal management approach that adopts a purely resilience framing, because a resilience lens focuses on changes at the system scale, rather than individuals or social groups at finer spatial scales within it. The differences in framing, scale, and epistemological standpoints of resilience and environmental justice are discussed further in section 8.3.2. This research's case study shows an intervention (sandscaping) designed to build geomorphological resilience may inadvertently create a risk of maladaptation, by reducing local residents' concern and perceived relevance of adapting to future coastal change e.g., managed realignment (post-sandscaping). Therefore, it could be argued that it is advantageous for both resilience and environmental justice perspectives to be applied to inform coastal management policy, to consider issues in challenging circumstances, (i.e. where it is relevant to consider multiple spatial and temporal scales for a coastal management intervention).

Secondly, it is clear from the empirical findings of this study that an environmentally just approach to coastal management is needed, so that local communities perceive the process of coastal decision-making as one of meaningful consultation and engagement. The empirical chapters, particularly Chapter 6, present local residents' perspectives that past and current coastal management has/does not sufficiently incorporate local views or keep residents updated with information on managing coastal change. Moreover, Chapters 5 and 6 reveal how perceived injustices in coastal management affect an individual's trust in local authorities and willingness to engage in coastal decision-making. Therefore, incorporating justice principles (that reflect issues of distribution, participation and recognition) into the process of coastal management decision-making would enable (a) to identify how residents are differently impacted, (b) to consult and/or involve residents in decision-making in ways perceived as meaningful and fair, (c) to understand how residents would like to frame the wider societal narrative of where they live, and (d) to facilitate a bottom-up community governance approach to coastal adaptation. This could be adapting via managed realignment, tailoring with policymaker's aspirations of the CTAP programme (see Chapters 6 and 7), or a different model put forward by local communities themselves. The knowledge gained through an environmentally just approach would also help coastal policymakers to target support and resources in adaptation policies within communities.

Lastly, this thesis has shown that an interdisciplinary approach provides a deeper insight into the impacts of coastal policy. Chapter 5 revealed that focussing on social perspectives as well as geomorphological performance adds greater insight into the effectiveness of sandscaping, a novel coastal management strategy. Meanwhile, Chapter 6 showed how sense of place and built cultural heritage, which are often more complex to define in economic terms, are nonetheless pivotal in shaping public perceptions of coastal management. Chapter 6 demonstrated there is currently a tension in what is valued: for instance in how coastal frontages are valued economically in current coastal policy, and how more pluralistic and non-monetary forms of value from the environmental justice field, such as people-place relations, may be considered. This is a key advantage of the environmental justice approach, in highlighting the importance of non-monetary forms of value in coastal decision-making. Combining an environmental justice approach with the current resilience approach to coastal management would therefore ensure more holistic decision-making on coastal areas beyond purely economic assessments. Moreover, recognising the social value of coastal areas and the tensions between perspectives at a variety of temporal and scalar levels, that emerges from an environmental justice approach, is vital information for coastal managers for facilitating relocation of community assets to new (inland) locations, ensuring social and cultural value attached to place is preserved in this transition.

9.3 Empirical insights from the research

The empirical chapters reveal several practical findings with regards to coastal management, nature-based solutions, and adaptation policy more broadly. Such insights are summarised here for policymakers, practitioners, academics, and other key stakeholders working in a coastal management or adaptation context in the UK or internationally. Insights are grouped according to scale, in terms of national (9.3.1) and local (9.3.2) recommendations.

9.3.1 National-level empirical insights

Funding and policy guidance on coastal adaptation

- Chapter 6 argues a **designated funding stream** for coastal adaptation is needed at a national level, so that local authorities have the finance and capacity to support communities in at-risk areas that are not defended by coastal protection schemes. This is echoed by local policymaker interviewees themselves in Chapters 6 and 7.
- A designated funding stream for coastal adaptation needs to be matched with **clear, practical policy guidance** for local authorities on how adaptation for managed realignment can be supported at a local level, and to remove current ambiguity and uncertainty that is evident in local policymaker reflections in Chapters 6 and 7.

Building social resilience to coastal change

- A key finding from the literature review (section 3.2.4) is that the current EA FCERM strategy (2020) focuses on increasing public risk perception, knowledge and awareness of coastal change ('capacity to prepare' factors) as a means to build social resilience to coastal change. Chapters 6 and 7 similarly find that policymaker interviewees discuss the aforementioned 'capacity to prepare' factors at greater length than other adaptive capacity factors reviewed in section 3.2.4. This suggests that policymakers, and policy guidance on coastal change, are currently focused on building social resilience to coastal change through increased knowledge and understanding of risk of erosion and flooding.
- As highlighted in Chapter 8, **community cohesion, sense of place and building trust between residents and policymakers**, which are 'capacity to

adapt' factors (Figure 3.3, section 3.2.4) are key barriers in this case study context for facilitating community engagement in coastal adaptation. Moreover, Chapters 5-7 reveal that Bacton, Walcott and Happisburgh residents are already highly aware of coastal change. Therefore, current coastal managed policy (EA, 2020) that focuses on building social resilience of at-risk communities through increasing knowledge and awareness of coastal risk is likely to have limited benefit, and overlooks the importance of building trust with local communities, community cohesion and addressing barriers associated with place attachment.

Policy announcements

- Chapter 6 highlights initial scepticism of CTAP amongst local residents, due to the length of time between the national announcement of the policy and communication at a local level about the programme (Coastwise). **National government departments could therefore delay new policy announcements at a national level** until the **required due diligence** is completed at a local level, so that public communication of new programmes are not followed by a period of silence, as perceived by local residents, in terms of a lack of subsequent policy information. A lack of information on new policies for managing coastal change could contribute to scepticism and distrust from a local community perspective.

Public communication on coastal adaptation

- **Language** on coastal adaptation, such as use of the words **'transition'** in CTAP, is **perceived by residents in Chapter 6 as vague** and unsubstantiated. Policymakers who are referring to coastal adaptation for an undefended coastline should provide greater detail on what specifically adaptation entails, to foster engagement and reduce scepticism in coastal management. Policymakers could also open up spaces for discussion within at-risk areas about what transition means to local communities, to help inform the programme.

9.3.2 Local level empirical insights

Deploying future sandscaping schemes or other novel nature-based solutions

- Findings from Chapter 5 indicate the need to **keep local residents updated** on geomorphological changes of sandscaping or other novel nature-based solutions, by **publicly disseminating environmental data post-implementation in an accessible, non-technical format on a regular basis.** This could be through regular updates in a newsletter format or a dedicated website (that publishes citizen science data, see recommendation below). This provides local residents with information about how their coast or local environment is changing, avoids unnecessary concern, and keeps residents engaged in local coastal management.
- Any public communication on novel environmental strategies should explicitly provide details to the general public on **the strengths, weaknesses and differences of nature-based solutions** in relation to pre-existing strategies, so that local communities understand how nature-based solutions may behave differently to, for example, previous hard defences. Chapter 5 reveals there can be scepticism of nature-based solutions and this might be compounded by the different (i.e. more invisible) mechanism by which it offers coastal protection. It is transient, not static, and can operate on a much larger scale than hard defences.
- Chapter 5 recommends that environmental or citizen engagement projects **explore the role of citizen science in monitoring** the evolution of nature-based solutions. Creating citizen science schemes may offer several co-benefits; providing additional data to local councils or project organisers, as

well as keeping local communities engaged and informed, and **improving the flow of information, communication and trust between residents and local authorities.**

- As argued in Chapter 5, novel coastal management, nature-based solutions or other environmental projects which are implemented within a local community should **continue with a dedicated community engagement officer** in the immediate years following implementation. With tight local authority budgets (or tight budgets in general for non-policy actors), **ring-fence funding** for post-implementation community engagement **in the overall budget** for the scheme.
- **Evaluations of novel environmental strategies (Chapter 5) should draw upon multiple perspectives,** such as qualitative data on the lived experience and perceptions of affected stakeholders, rather than solely focussing on geomorphological (or environmental) performance.

Insights for coastal communities adapting to coastal change under a managed realignment policy scenario

- **Chapters 5-7 find, as a cross-cutting theme, that increasing the dissemination of information on coastal change, diversifying communication channels, and increasing trust** with local communities appear relevant objectives for community engagement in coastal adaptation.
- Chapter 6 argues that policies designed to support communities transitioning from retreating coastlines should **include emotional support as well as the needed financial and practical support.** Community engagement needs to be mindful of, and consider, how a positive scenario and future vision can be created for settlements under managed realignment. **Transition plans** need to offer communities a narrative, **that works with sense of loss** and place disruption from coastal erosion and flooding. Chapter 6 highlights the

importance of communities defining the narrative of the future of their settlement.

- It is likely that practitioners, policymakers and other stakeholders working within a coastal adaptation context will **encounter wide differences of opinion, and some residents who may not want to engage** in conversations about future coastal management, for a variety of reasons (as evidenced in Chapters 5-7). **Facilitating community engagement beyond traditional engagement routes** (i.e. beyond pre-established community groups and parish councils), could assist with reaching and offering opportunities for involvement to a greater number of local residents.
- Local communities with current defences of residual life, or protected by schemes such as sandscaping, may perceive the need for transition, or relocating assets, as outside of their lifetime (a key finding in Chapter 7). It may be challenging to involve and persuade some residents under such contexts on the need for anticipatory adaptation. **An intergenerational justice framing of coastal issues** could be a useful framing for practitioners, policymakers, or other stakeholders seeking to initiate these discussions, where the importance of adaptation is framed from the perspective of future members of the community.

Appendix 1. Survey questions and accompanying information sheet

Two years of the Bacton-Walcott Sandscaping scheme
Local community experiences

Please read the accompanying information sheet before completing this survey.
This survey has a total of 24 questions and will take around 20 minutes to complete.

Section 1. Experiences of the Sandscaping scheme

This section asks about your views and experiences of the Bacton-Walcott Sandscaping scheme

1. Which village do you live in?

☐ Bacton

☐ Walcott

☐ Happisburgh

☐ Other (please name the area you live in):______________________________

2. Have you heard of the Bacton-Walcott Sandscaping scheme?

☐ Yes

☐ No

If 'yes', what do you think the **purpose** of the Sandscaping scheme is?

____

____

3. Have there been any **positive impacts** of the Sandscaping scheme to you and/or the village you live in? If yes, please specify what these positive impacts are.

For me individually:

____

____

For my village:

____

____

4. Have there been any **negative impacts** of the Sandscaping scheme to you and/or the village you live in? If yes, please specify what these negative impacts are.

For me individually:

____

____

For my village:

____

____

5. Do you think the Sandscaping scheme has impacted people within your village similarly?

☐ Yes

☐ No

☐ Don't know

Please briefly explain your answer:

____

____

____

6. **In the next 5-10 years**, how do you think the Sandscaping scheme will impact **you individually?** Please tick the most appropriate box.

Largely negatively	Somewhat negatively	Neither positively or negatively	Somewhat positively	Largely positively	Don't know

7. **In the next 5-10 years,** how do you think the Sandscaping scheme will impact **your village?** Please tick the most appropriate box.

Largely negatively	Somewhat negatively	Neither positively or negatively	Somewhat positively	Largely positively	Don't know

8. Please explain your answers to questions 6 and 7 in your own words here (i.e. why you think the Sandscaping scheme will impact you and your village positively or negatively in the future).

For me individually:

____

____

For my village:

____

____

9. Has the Sandscaping scheme changed your use of the coast at Bacton and/or Walcott?

☐ Yes

☐ No

☐ Not applicable

If yes, please explain how:

____

____

Section 2. Managing coastal change

This section asks for your views on your local area, and managing coastal change in your village.

10. Has the Sandscaping scheme altered your views on how coastal change (i.e. coastal erosion and flooding) could be managed in your village?

☐ Yes

☐ No

Please briefly explain why:

____

____

11. What do you think causes coastal change in your village? Please tick all that apply, and write the most important cause in the comment line underneath.

☐ Natural coastal processes

☐ Water runoff/poor drainage

☐ Sea level rise and/or more intense or frequent storms

☐ Hard coastal defences

☐ Building/developments by the sea

☐ Other (please specify):____

Most important cause:
____

12. Who do you think is/are responsible for managing coastal change on the Norfolk coast? Please tick all that apply.

☐ National government or institutions (e.g. Environment Agency, DEFRA, CEFAS)

☐ Local government (e.g. county or district councils)

☐ Local businesses

☐ Local communities

☐ Other (please specify):____

13. Has your view of **who** is responsible for managing coastal erosion stayed the same, or changed, **since Sandscaping was introduced** in July 2019? (If it has changed, please briefly explain why)

☐ No – my view hasn't changed

☐ Don't know

☐ Yes – (please explain why)

____

____

14. How do you think Sandscaping will affect coastal change in your village over the next **15-20 years?**

☐ Sandscaping will have no effect on coastal change in my village

☐ Sandscaping will slow the rate of coastal change in my village

☐ Sandscaping will increase the rate of coastal change in my village

☐ Sandscaping will stop coastal change from happening in my village

☐ Don't know

15. Do you think Sandscaping will affect the rate of coastal erosion in any **neighbouring** villages to you? (If yes, please state how, and where).

☐ No

☐ Don't know

☐ Yes (please state how, and where):

16. What coastal management, if any, do you think should happen in your village **in 15-20 years,** which is after the projected lifetime of the Sandscaping scheme?

17. Other than Sandscaping, do you think **any actions could be taken now** to prepare for future coastal change in your village (and are you aware of anything happening in your village at present?)

Actions that could be taken now

Actions already happening

18. Please indicate the extent to which you agree or disagree with the following statements. Please tick the appropriate option for each statement.

	Strongly disagree	Partially disagree	Neither agree nor disagree	Partially agree	Strongly agree
I feel attached to my village					
My job/ income is attached to my village					
I would regret having to move to another village					
I feel part of a community in my village					
I trust that coastal change is managed appropriately in my village					

19. In your opinion, does your local area have sufficient access to local services and resources (such as healthcare, education and training, utilities) **that you are able to make use of?**

☐ Yes

☐ No

Please explain your answer

____

____

____

20. How long would you be able to withstand financial loss due to coastal erosion or flooding? (Financial loss could be direct, e.g. property damage, or indirect, e.g. loss of revenue)

☐ Less than 1 month/this would impact me straight away

☐ 1-5 months

☐ 6 months – 1 year

☐ Over 1 year

☐ Don't know

☐ Not applicable

21. In the event of a coastal flood or coastal erosion, do you have a friend or family member who could help you, if your property or village was impacted (e.g. damaged, left without utilities, services, transport)?

☐ Yes

☐ No

☐ Don't know

☐ Not applicable

Section 3. About you

This final section asks for a few anonymised details, so we know how representative our survey is.

22. How long have you lived in Bacton, Walcott or Happisburgh?

☐ Less than 3 years

☐ 3-10 years

☐ 11-20 years

☐ Over 20 years

23. Is this your primary residence or a second home?

☐ Primary residence

☐ Second home (if so, roughly how much of the year do you stay here?) (e.g. 6 months)

24. What age group are you in?

☐ 18 – 24

☐ 25 – 34

☐ 35 – 44

☐ 45 – 54

☐ 55 - 64

☐ 65 - 74

☐ 75+

Thank you for your time completing this survey.

As part of this research, we will also be interviewing residents of Bacton, Walcott, and Happisburgh covering similar topics to this survey.

If you would like to be further involved in this research, please leave a contact detail (email or phone number) below and we can send you more information.

This is entirely optional. The interview would not in any way be linked to your responses to the survey, which will be reported anonymously. Your contact details will be kept strictly confidential, and absolutely not passed to anyone else.

Contact details

Survey information sheet

What is this survey about?

You are invited to complete this survey as a resident of Bacton, Walcott or Happisburgh. This study is part of a publicly funded research project (PhD) at the University of East Anglia (UEA) on community experiences of living with the Sandscaping scheme, which was implemented at Bacton and Walcott over two years ago in summer 2019. This research contributes to ongoing work about sandscaping. The survey asks about your views and experiences of the scheme, and your views on coastal change.

Why should I complete this survey?

This survey is completely voluntary. By completing this survey, you are contributing to our understanding of the impacts of sandscaping on local communities. North Norfolk is the first coastal area in the UK to use sandscaping, with several other areas interested in replicating the scheme. Understanding how communities are impacted can help inform future schemes. The research team (a PhD researcher and three supervisory staff members) are strictly independent of North Norfolk District Council, but will share research findings at the end of the project. This survey does not require any in-depth knowledge of the sandscaping scheme and we would like to get the views from as many residents as possible.

How to complete the survey

This survey has a total of 24 questions, and is expected to take around 20 minutes to complete.

Surveys will be collected over the doorstep on Monday 31st January and Tuesday 1st February. Please leave it outside your door or in a porch, in a plastic bag and weighed down by a stone or can of tinned food to avoid it being blown away in windy weather. This survey has been distributed using PPE (gloves and hand sanitizer) to protect from Covid-19.

Alternatively, this survey is available to complete online. If you would prefer to fill out this survey online, please visit: https://www.surveymonkey.co.uk/r/MMQ2RXJ

Please only complete this survey once. By completing this survey, you are consenting to take part in the study. It will not be possible to withdraw your answers after completing the survey.

How this information will be used and stored

This survey does not ask for information that would allow respondents to be personally identified, and has kept demographic questions (e.g. age) to a minimum. All respondents will remain anonymous, and answers confidential to the research team on a password protected computer, in accordance with the Data Protection Act (2018) and UK General Data Protection Regulation (UK GDPR), and the University of East Anglia's Research and Data Management Policy. Any results reported in research articles will be anonymized. This survey has received ethics approval from the UEA DEV ethics committee.

Where can I find out more information?

For any queries about this research or to discuss it further, please contact the researcher:

Isabel Cotton, PhD Researcher, University of East Anglia, i.cotton@uea.ac.uk

If you have any queries about the survey, please contact Dr Johanna Forster (**j.forster@uea.ac.uk**)

Thank you for taking the time to complete this survey and supporting this research

Appendix 2. Interview questions and information sheet – Bacton and Walcott residents

University of East Anglia

Conversation on coastal change with local residents

Information sheet

What is this research about?

This study is part of a NERC-ESRC funded research project (PhD) at the University of East Anglia (UEA), researching local residents views and experiences of the Bacton-Walcott sandscaping scheme, and on managing flood and erosion risk. I am inviting local residents to take part in an interview, to gather people's views on this.

What will the interview be about?

I would like to talk to Bacton, Walcott and Happisburgh residents about the sandscaping scheme and how future coastal risk can be best managed. In particular, I am interested in what local residents think about sandscaping as a coastal management strategy, their experience of it (if any), and their views on community involvement in future coastal management decision-making. These conversations follow-on from a public survey I ran in January and February 2022. You can take part in an interview even if you weren't invited to complete the survey.

Why should I take part?

It is completely voluntary to take part in an interview. By taking part, you are contributing to our understanding of the impacts of sandscaping and coastal change on local communities. Bacton and Walcott is the first coastal area in the UK to use sandscaping, with a few other areas interested in replicating the scheme. Meanwhile, this year the Environment Agency launched a new programme on how coastal change can be best facilitated for at-risk coastal areas. Understanding community perspectives is important in the design of any future coastal management projects. This research project shared summary findings of the public survey with North Norfolk District Council, and will do so again at the end of the research. I can also share a summary of research findings with you at the end of the project, if you are interested in receiving this.

When and how will the interview take place?

The interview can take place in-person, over the phone, or online – whatever you prefer. I anticipate it would take 30 mins - 1 hour, but it can be shorter or longer than this, depending on your availability. The interview questions on page 3 are a rough guide, and we don't have to discuss all questions. We can stop the interview at any time.

How this information will be used and stored

I would like to use a dictaphone so I can record and listen back to our conversation, but it is entirely your choice if you are happy for the conversation to be recorded. No one else will have access to the recording and transcript apart from myself (the lead researcher, contact details overleaf), which I will delete at the end of my PhD. Any results reported in research articles will be anonymized. Notes or recordings of the interview will be stored on a password protected computer and kept no longer than necessary, in accordance with the Data Protection Act (2018) the UK General Data Protection Regulation (UK GDPR), and the University of East Anglia's Research and Data Management Policy.

This study has received ethics approval from the UEA DEV ethics committee. By completing this interview, you are consenting to take part in the study. It will not be possible to withdraw your participation after completing the interview. The research team (a PhD researcher and three supervisory staff members) are strictly independent of North Norfolk District Council.

Where can I find out more information?

For any queries about this research or to discuss it further, please contact myself, the lead researcher:

Isabel Cotton, PhD Researcher, University of East Anglia, i.cotton@uea.ac.uk

If you have any other queries about the research, please contact Dr Johanna Forster (j.forster@uea.ac.uk)

Thank you for your time supporting this research.

If you would like to take part in the interview, please sign and date below:

I have read the above information sheet and I am happy to take part in the research.

Name:

Date:

Conversation on coastal change with local residents

Question guide

Part 1. I would like to learn more about the local communities here, and any community involvement in coastal change issues:

What do you consider to be 'your local community' (i.e. where and whom does this encompass)?

Do you feel there is a strong sense of community there?

For the village you live in, how would you like coastal management decisions about at-risk areas to be made?

Do you think local residents have any role to play in managing coastal flood or erosion risk in your village?

If yes, in your opinion, who amongst the community should be involved?

Part 2. I would like to ask about your views on the Bacton-Walcott sandscaping scheme, and managing future coastal change in your village:

What official communication have you had about sandscaping, and what, if any, information would you like to receive about the sandscaping in the future?

Do you think that sandscaping is an 'effective' strategy? How do you think it compares to previous forms of flood and erosion risk reduction such as sea walls or timber revetments at Bacton/Walcott?

In the public survey I ran in January this year, some residents reported peace of mind from the sandscaping scheme. Has the sandscaping scheme made you think more/less/or no change, about the risk of coastal erosion or flooding after sandscaping has gone?

What would you like to see happen, at the end of the modelled lifetime of sandscaping (expected to be in about 15 years' time)?

What do you think the next steps for managing the coast in your village are now, given the scheme is expected to be in place for about 15-20 years?

Have you heard of the Coastal Transition Accelerator Programme, which was awarded to North Norfolk District Council this year? If yes, what do you hope it will achieve?

Is there anything else you'd like to mention or talk about?

Appendix 3. Interview questions and information sheet – Happisburgh residents

Conversation on coastal change with local residents

Information sheet

What is this research about?

This study is part of a NERC-ESRC funded research project (PhD) at the University of East Anglia (UEA), researching local residents views of managing coastal flood and erosion risk, and the Bacton-Walcott sandscaping scheme. I am inviting local residents to take part in an interview, to gather people's views on this.

What will the interview be about?

I would like to talk to Bacton, Walcott and Happisburgh residents individually about the sandscaping scheme and how future coastal risk can be best managed. For Happisburgh residents, I am interested in what residents think about managing the risk of coastal change, and their views on community involvement in any decisions on Happisburgh's coast. These conversations follow-on from a public survey I ran in January and February 2022. You can take part in an interview even if you weren't invited to complete the survey.

Why should I take part?

It is completely voluntary to take part in an interview. By taking part, you are contributing to our understanding of the impacts of sandscaping and coastal change on local communities. Bacton is the first coastal area in the UK to use sandscaping, with a few other areas interested in replicating the scheme. Meanwhile, this year the Environment Agency launched a new programme on how coastal change can be best facilitated for at-risk coastal areas. Understanding community perspectives is important in the design of any future coastal management projects. This research project shared summary findings of the public survey with North Norfolk District Council, and will do so again at the end of the research. I can also share a summary of research findings with you at the end of the project, if you are interested in receiving this.

When and how will the interview take place?

The interview can take place in-person, over the phone, or online – whatever you prefer. I am in the area and around to meet in person from 11th-18th October. I anticipate it would take 30 mins - 1 hour, but it can be shorter or longer than this, depending on your availability. The interview questions on page 3 are a rough guide, and we don't have to discuss all questions. We can stop the interview at any time.

How this information will be used and stored

I would like to use a dictaphone so I can record and listen back to our conversation, but it is entirely your choice if you are happy for the conversation to be recorded. No one else will have access to the recording and transcript apart from myself (the lead researcher, contact details below), which I will delete at the end of my PhD. Any results reported in research articles will be anonymized. Notes or recordings of the interview will be stored on a password protected computer and kept no longer than necessary, in accordance with the Data Protection Act (2018) the UK General Data Protection Regulation (UK GDPR), and the University of East Anglia's Research and Data Management Policy.

This study has received ethics approval from the UEA DEV ethics committee. By completing this interview, you are consenting to take part in the study. It will not be possible to withdraw your participation after completing the interview. The research team (a PhD researcher and three supervisory staff members) are strictly independent of North Norfolk District Council.

Where can I find out more information?

For any queries about this research or to discuss it further, please contact myself, the lead researcher:

Isabel Cotton, PhD Researcher, University of East Anglia, i.cotton@uea.ac.uk

If you have any other queries about the research, please contact Dr Johanna Forster (j.forster@uea.ac.uk)

Thank you for your time supporting this research.

If you would like to take part in the interview, please sign and date below:

I have read the above information sheet and I am happy to take part in the research.

Name:

Date:

Conversation on coastal change with residents

Question ideas

Part 1. I would like to learn more about the local communities here, and any community involvement in coastal change issues:

What do you consider to be 'your local community' (i.e. where and whom does this encompass)?

Do you feel there is a strong sense of community there?

For the village you live in, how would you like coastal management decisions about at-risk areas to be made?

Do you think local residents have any role to play in managing coastal erosion risk in your village?

If yes, in your opinion, who amongst the community should be involved?

Part 2. I would like to ask about your views on the Bacton-Walcott sandscaping scheme, and managing future coastal change in Happisburgh:

Do you think that sandscaping in Bacton is an 'effective' strategy? How do you think it compares to previous forms of flood and erosion risk reduction such as sea walls or timber revetments at Bacton/Walcott?

How do you think uncertainty around coastal risk affects decision making about coastal management for your village?

What do you think the next steps for managing the coast in your village are now?

Have you heard of the Coastal Transition Accelerator Programme, which was awarded to North Norfolk District Council this year? If yes, what do you hope it will achieve?

Is there anything else you'd like to mention or talk about?

Appendix 4. Interview questions and information sheet - policymakers

PhD research project (2020-2024) on the Bacton-Walcott sandscaping scheme and managing coastal change

Information sheet

What will the interview be about?

I would like to talk to local and national policymakers, either involved in managing coastal change in the area of North Norfolk I am researching (Bacton, Walcott and Happisburgh), or involved in coastal adaptation or resilience policy programmes at a national level. In particular, I am interested in policymakers perspectives on the Bacton-Walcott sandscaping scheme, and the current Coastal Transition Accelerator Programme. The interview questions are a rough guide; we don't have to discuss all questions, and can talk about other topics you feel are relevant.

Why should I take part?

It is completely voluntary to take part in an interview. This study is part of a publicly funded research project (PhD) at the University of East Anglia (UEA), looking at the impacts of sandscaping and coastal change on the communities of Bacton, Walcott and Happisburgh in North Norfolk. North Norfolk is the first coastal area in the UK to use sandscaping, with several other areas interested in replicating the scheme. The research team (a PhD researcher and three supervisory staff members) are strictly independent of North Norfolk District Council, but will share research findings at the end of the project.

When and how will the interview take place?

The interview will take place online, over Microsoft Teams, at a time convenient to you. I anticipate it could last 30 mins – 1 hour, but it can be shorter or longer than this, depending on your availability.

How this information will be used and stored

I would like to record our meeting so I can transcribe and listen back to our conversation, but it is entirely your choice if you are happy for the conversation to be recorded. No one else will have access to the recording apart from myself (the lead researcher, contact details below), which I will delete at the end of my PhD. Any results reported in research articles will be anonymized. Notes or recordings of the interview will be stored on a password protected computer and kept no longer than necessary, in accordance with the Data Protection Act (2018) and UK General Data Protection Regulation (UK GDPR), and the University of East Anglia's Research and Data Management Policy. This study has received ethics approval from the UEA DEV ethics committee.

By completing this interview, you are consenting to take part in the study. It will not be possible to withdraw your participation after completing the interview.

Where can I find out more information?

For any queries about this research or to discuss it further, please contact the lead researcher:

Isabel Cotton, PhD Researcher, University of East Anglia, i.cotton@uea.ac.uk

If you have any other queries about the research, please contact Dr Johanna Forster (j.forster@uea.ac.uk)

If you would like to take part in the interview, please sign and date below:

I have read the above information sheet and I am happy to take part in the research.

Name:

Date:

Thank you for your time supporting this research.

PhD research project (2020-2024) on the Bacton-Walcott sandscaping scheme and managing coastal change

Interview guide

The below interview questions are a rough guide; some may not be applicable to you, we don't have to discuss all questions, and can talk about other topics you feel are relevant.

1. Can you tell me a bit about your role, and work in coastal management at a local or national level?

Part 1. Bacton-Walcott sandscaping scheme

2. From your work, are you aware of the Bacton-Walcott sandscaping scheme, which was implemented in North Norfolk in 2019 and is the first scheme of its kind in the UK?

If yes:

3. Whilst sandscaping is in place, what do you envisage would happen for coastal management in Bacton and Walcott, and for Bacton Gas Terminal?

4 What, from your perspective, are the next steps for managing the coast at Bacton and Walcott after sandscaping?

5. Is there a possibility the sandscaping scheme will be repeated at the end of its lifetime, and what is this dependent on?

6. Are there any plans for follow-up engagement with local residents about the sandscaping scheme and how its evolving?

7. How do you perceive the level of engagement and trust between the villages of Bacton and Walcott, and nearby Happisburgh, and local authorities on coastal change issues? Has this changed over time?

8. Do you think anything else could be done/provided to better support coastal management at Bacton and Walcott?

9. Are you aware of any plans to introduce sandscaping elsewhere in the UK?

Part 2. Coastal Transition Accelerator Programme (CTAP)

10. Will you or your organisation be involved in the Coastal Transition Accelerator Programme, and how?

11. What are your expectations for the Coastal Transition Accelerator Programme? What do you hope it will achieve?

12. What actions will be trialled as part of the programme?

13. How, if at all, will local communities be involved?

14. Do you envisage any updates or changes to the North Norfolk District Council EN12 policy *(Relocation and Replacement of Development Affected by Coastal Erosion Risk)* from the programme?

Part 3. Coastal change now and into the future

15. From your perspective, what are the key challenges, currently, to facilitating coastal adaptation?

16. Do you see any major challenges for the management of the Norfolk coast in the next 2-3 decades?

17. What information is used to inform the National Coastal Erosion Risk Mapping (or in Norfolk, the Coastal Erosion Constraint Area), and how regularly is this updated?

18. Is there anything else you'd like to mention or talk about?

Appendix 5 – Survey results

Q1. Which village do you live in?

Bacton (n=48)
Walcott (n=29)
Happisburgh (n=23)

Q2. Have you heard of the Bacton-Walcott Sandscaping scheme?

98% 'yes'

If 'yes', what do you think the purpose of the sandscaping scheme is?

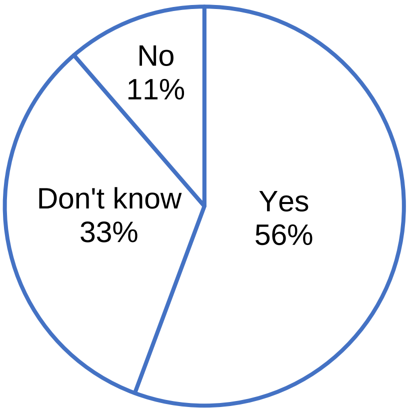
Protection, slowing down, alleviating, halting flooding & erosion – terminal, villages, coastal road, cliffs & beaches
48% answers chose to emphasise protecting gas terminal is sole or primary purpose

Q3. Have there been any positive impacts of the sandscaping scheme to you and/or the village you live in? and Q4. Have there been any negative impacts of the sandscaping scheme to you and/or the village you live in?

Main theme (impact)	Codes
No flooding/ erosion	-No flooding or erosion events and associated physical impacts (property damage, inundation, house shaking, sea spray, overtopping of sea wall, cliff collapses).
Bigger/ sandier beach	-Restorative benefits of having a wider, bigger, sandier beach. -More attractive beach and coastal scenery. -Change (reverting back) to how beach used to look in the past.
Recreational opportunities	-Recreational benefits, with calmer sea for swimming, kayaking, sunbathing, bird watching, and new shallow areas in the sea. -Cleaner beach /less rubbish washed up.
Physical access/ safety getting on/off beach	-Permanence of access for different parts of beach at all times of day (e.g. including during high tide). -Now possible to walk between villages along the coast. -Improved physical access and safety in getting on/off beach for wheelchair users/ users with reduced mobility.
Reassurance/ peace of mind	-Mental health benefits of greater reassurance, peace of mind, and reduced anxiety about flood or erosion risk and impacts.
Increased property value	-Perceived financial benefits from increased property value and the village being a more desirable place to live. -Not incurring financial expense from flood or erosion property damage.
Coast road stays open	-The main road connecting the villages of Bacton and Walcott to other parts of the coast does not flood, providing reliability for transport and access.
More visitors and trade	-More visitors to beach, more trade to shops, cafes, pubs. Village thrives and has financial viability.
More people using beach	Greater numbers of tourists and visitors to the beach.
Impact of more visitors	Impact of more visitors: - Cars (traffic, inconsiderate parking blocking houses and roads, visitors not using car parking provided, nowhere to park in village). - Litter (more dog waste and other litter). - Antisocial behaviour, petty crime.

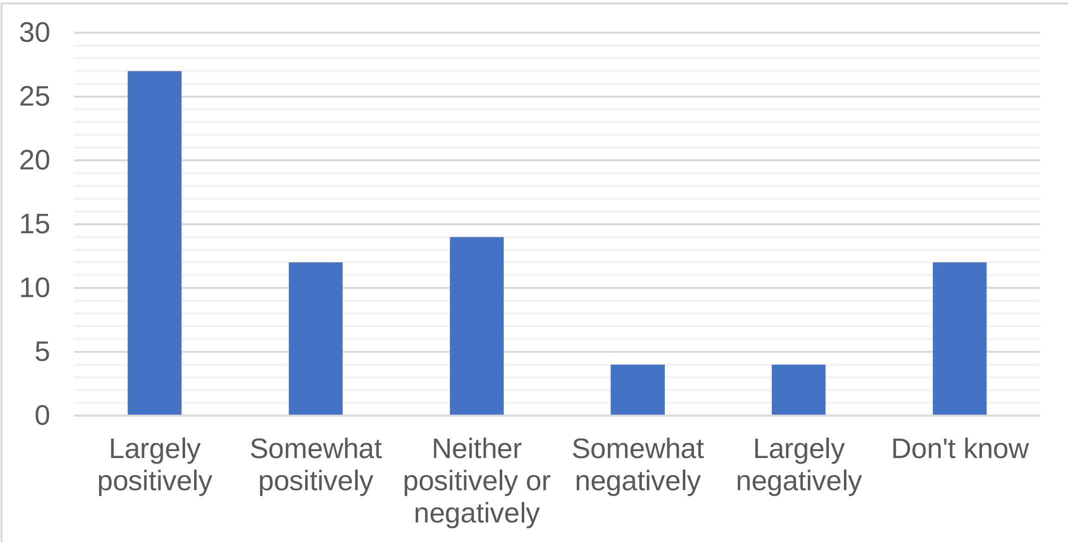
Wind-blown sand	-Wind-blown sand into gardens, open windows, car screens, blocking gutters/ drains, damage to outdoor equipment, and depositing around the village. -Required locks to be taped over and financial cost and stress to clean-up houses and gardens.
Change in physical access to beach	-Access to beach is harder due to slopes, the loss of concrete path along the beach by sea wall makes it harder to walk for some (prams, wheelchairs). Some areas now closed. -Change in aesthetic to beach (appears scruffier) -Safety issues of groynes partially or fully submerged by sandscaping.

Q5. Do you think the Sandscaping scheme has impacted people within your village similarly? (n=97)

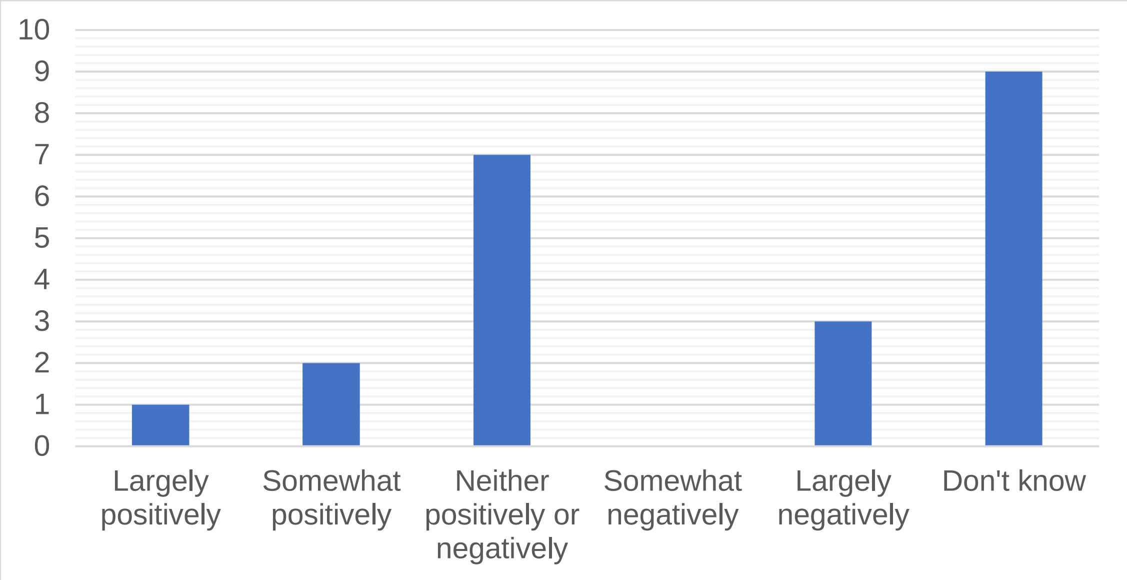


Q6. In the next 5-10 years, how do you think the Sandscaping scheme will impact you individually?

Bacton and Walcott, n=73

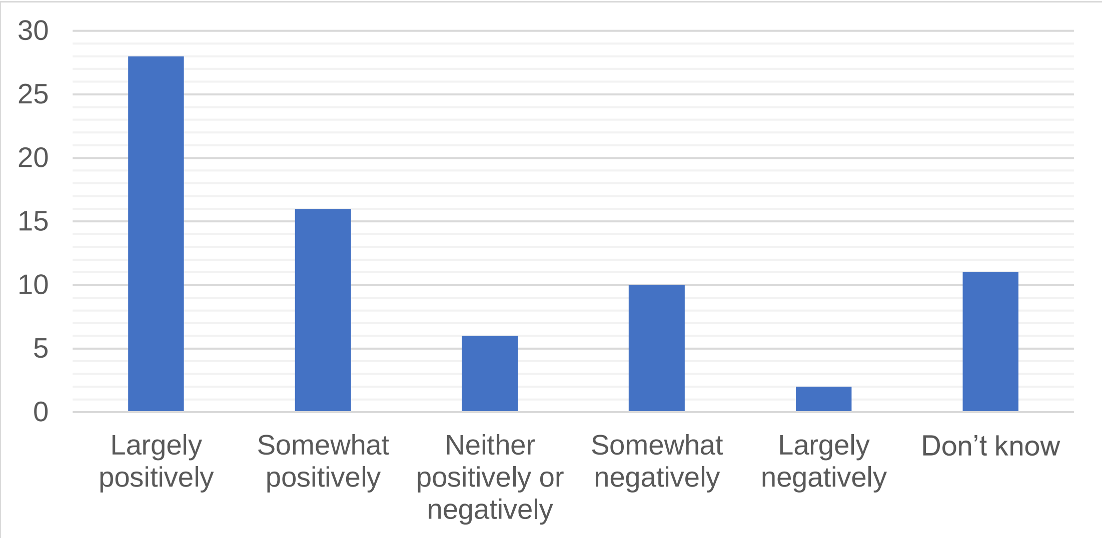


Happisburgh, n=22

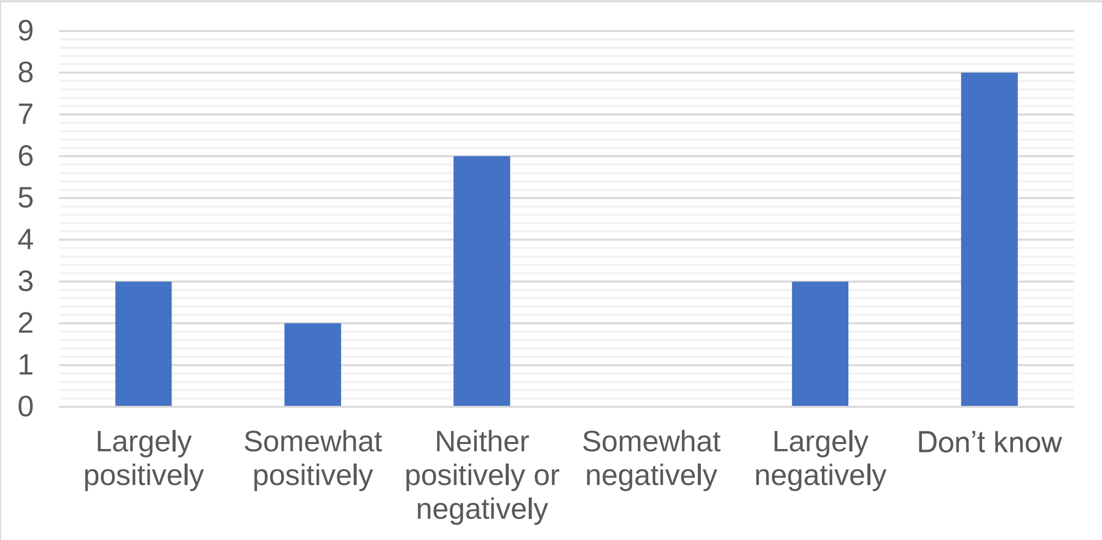


Q7. In the next 5-10 years, how do you think the Sandscaping scheme will impact your village?

Bacton and Walcott (n=73)



Happisburgh (n=22)



Q8. Please explain your answers to questions 6 and 7 in your own words here (i.e. why you think the sandscaping scheme will impact you and your village positively or negatively in the future)

37% answers show doubt or negative perceptions (n=93).

Of this:

10% Don't knows/ too soon to tell

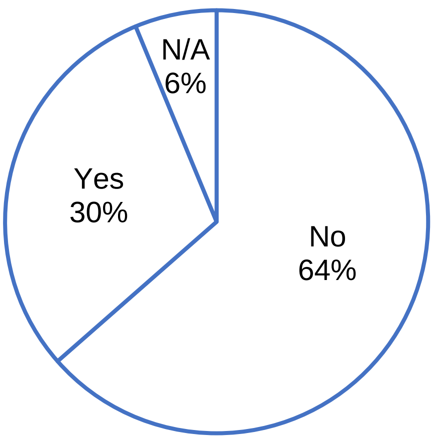
11% general scepticism of scheme

10% won't last/ sand gone/ call for sand to be topped up

4% feeling overwhelmed (H'bro)

2% makes no difference to me

Q9. Has the Sandscaping scheme changed your use of the coast at Bacton and/or Walcott? (n=96)



If ‘yes’ please explain why’ (typical examples include):

- Visit beach more often
- Better (and worse) access– changed route for walkers/ dog walkers
- Beach busier
- Better experience on beach – e.g. waves
- Safer recreation - swimming
- Don’t do some activities anymore e.g. fossil hunting

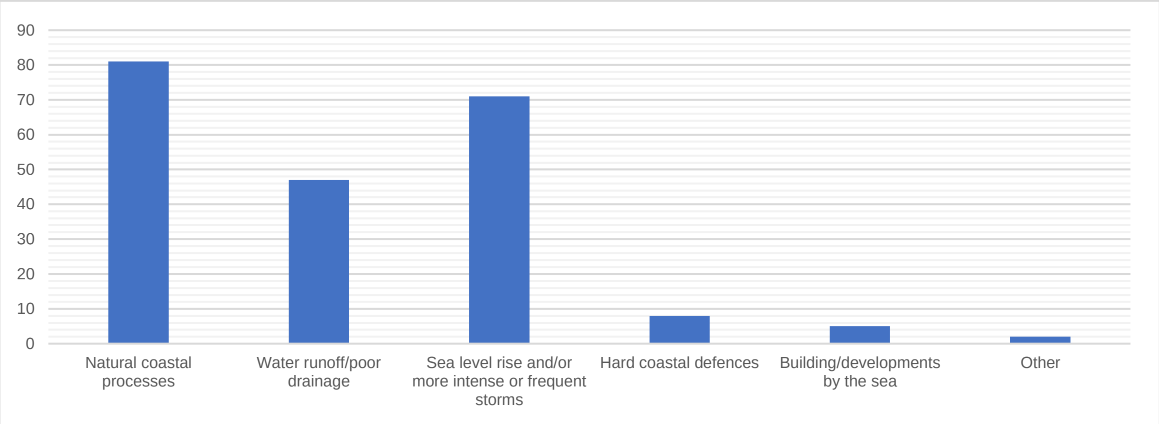
Q10. Has the Sandscaping scheme altered your views on how coastal change (i.e., coastal erosion and flooding) could be managed in your village? (n=90 for closed-text question, n=74 for open-text comment box)

49% Yes
51% No

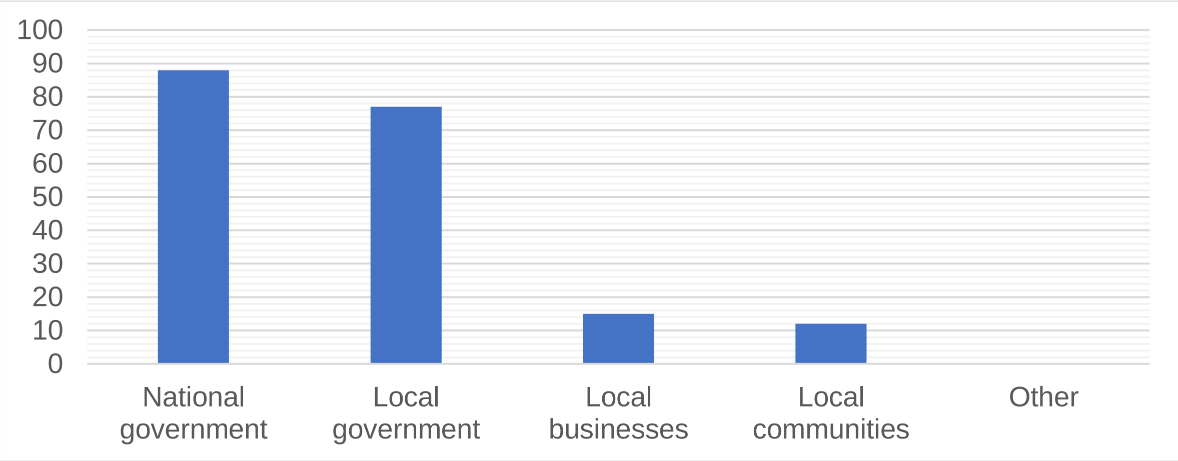
Step 1: Initial coding	Step 2: focussed coding	% answers (step 2)	Step 3: theoretical coding
Already taking protective measures, aware of Lincshore, already aware of erosion issue	Already aware	4%	
not aware of sandscaping previously, didn’t know would work on this scale, initially sceptical, changed opinion, feel less hopeless, increased knowledge	Raised awareness/ opinion change	14%	Indirect impacts of sandscaping
Sandscaping doesn't fully protect coast, stop cliff erosion, hard defences sturdier, sandscaping not fully effective, need further defences, not implemented sucessfully, partially works	Hard defences needed/ would have been better	22%	Perceptions of managing future coastal change
need to do better, no viable solution, can't work forever, putting off the inevitable, slows but doesn't solve issue	Just delaying inevitable	8%	Temporal impacts
Sand building up, it should continue, less flooding, altered beach, feel protected, not experienced any impacts, technology working, can monitor effectively, more positive, better than hard defences	Evidence / it works	39%	Perceptions of managing future coastal change
Need large amount funding, future funding, area not valued, needs future funds to keep going, needs topping up	Funding for future	12%	Perceptions of managing future coastal change

Lots of sand gone, won't last	Insufficient evidence will work in future	16%	Temporal impacts
Causes less impacts elsewhere, causes more impacts elsewhere, impacts further down coast, risk of impacts elsewhere, reduces unintended impacts	Unintended impacts	5%	Spatial and temporal impacts
Don’t know, other		9%	

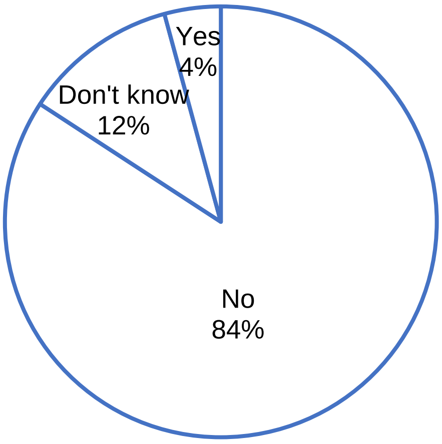
Q11. What do you think causes coastal change in your village? (tick all that apply) (n=94)



Q12. Who do you think is/are responsible for managing coastal change on the Norfolk coast? (tick all that apply) (n=96)

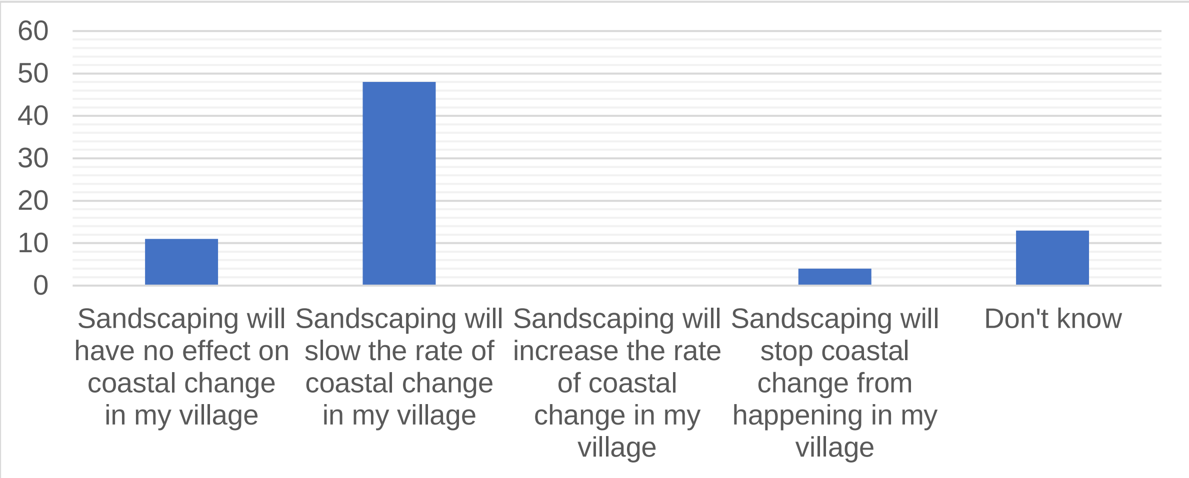


Q13. Has your view of who is responsible for managing coastal erosion stayed the same, or changed, since Sandscaping was introduced in July 2019? (n=95)

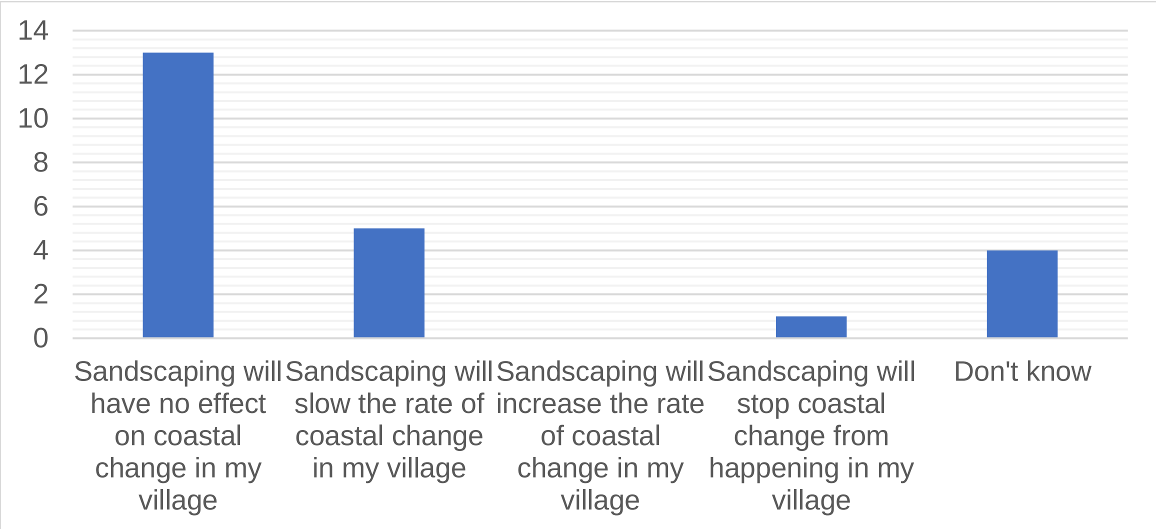


Q14. How do you think Sandscaping will affect coastal change in your village over the next 15-20 years?

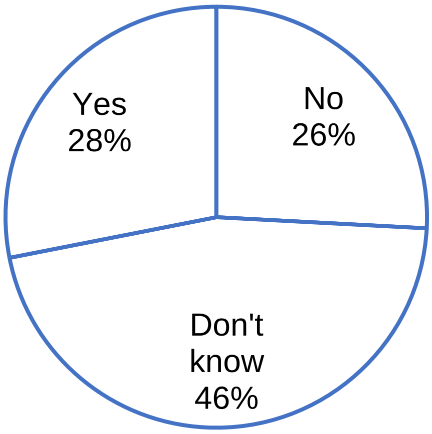
Bacton and Walcott, n=76



Happisburgh, n=23



Q15. Do you think Sandscaping will affect the rate of coastal erosion in any neighbouring villages to you? If yes, please explain how/where (n=89)



If yes (open-text comment box, typical responses):

- It will help neighbouring villages, albeit temporarily (22 responses)
- It will make erosion worse in neighbouring villages (12 responses)

Q16. What coastal management, if any, do you think should happen in your village in 15-20 years, which is after the projected lifetime of the Sandscaping scheme? (n=88)

Step 1: Initial coding	Step 2: focussed coding	% answers (step 2)	Step 3: theoretical coding
More sandscaping - (repeat, extend, top-up)	More sandscaping	41%	no mention of building community resilience, adaptive preference, perceptions of who manages coastal change,
Hard defences - new, existing, several, in addition to sandscaping, as alternative to sandscaping, removed, expanded. Reefs, sea wall, revetments, groynes, rocks, sea defences in general, sand grass/islands, breakwaters	Hard defences	30%	As above
Being overlooked/ insignificant, second in priority to terminal, more funding/ action needed	Being overlooked/ insignificant	14%	Recognitional injustice,

			distributional injustice
Issue not appropriately addressed, sandscaping not lasted/ waste of money, at high risk, more effective/ longer-term solution needed, too late	Scepticism/ of sandscaping	13%	Perceptions of coastal change, lack of trust/belief (barriers to community resilience)
If successful, if financially viable, if terminal still operating, if monitoring (that’s positive)	Contingent on	16%	Uncertainty that comes with sandscaping
anything that works, unknown, not expert, after my time	‘Something’/ unknown	13%	Perceptions of who manages coastal change

Q17. Other than Sandscaping, do you think any actions could be taken now to prepare for future coastal change in your village (and are you aware of anything happening in your village at present?) (n=76)

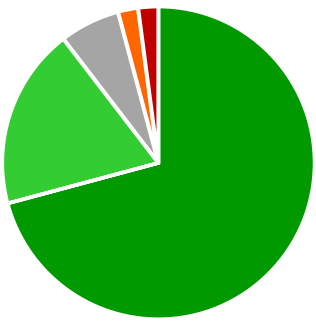
Step 1: Initial coding	Step 2: focussed coding	% answers (step 2)	Step 3: theoretical coding
nothing else needed/ appropriate, no, none	None	11%	building social (community) resilience, managing future coastal change, temporal impacts
not known, unsure, don't know, not qualified to answer	Not known	9%	As above
new, reinstate, expand current area, maintain hard defences	More/ maintained hard defences	41%	Managing future coastal change
lack of government support, interest, information, money	Resources/ support	9%	Distributional impacts/ recognitional injustice
revert to previous defences/ approaches, wrongly abandoned	Revert to old approach	9%	
can't stop the inevitable/ tides, too big an issue, nothing will happen	inevitability	4%	Temporal impacts

keep coastline clean, litter free, monitoring, early intervention, ring fenced budget	Maintain current state	8%	Indirect impacts of sandscaping (managing coastal change)
improve drainage, reduce runoff	Improve drainage	7%	
something needs to be done, coast at high risk	Action urgently needed/ 'something'	9%	
soft engineering, community consultation, community preparation, climate change mitigation, early intervention, '/'	Other	9%	

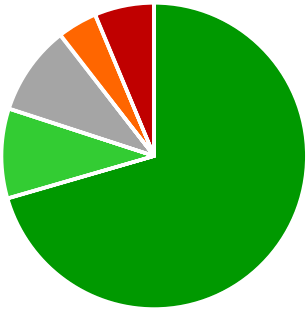
Q18. Please indicate the extent to which you agree or disagree with the following statements (n=94/95)

Strongly agree
Partially agree
Neither agree nor disagree
Partially disagree
Strongly disagree

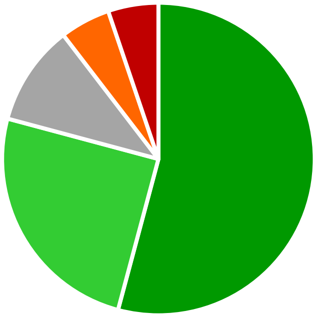
I feel attached to my village



I would regret having to move to another village



I feel part of a community in my village



I trust that coastal change is managed appropriately for my village

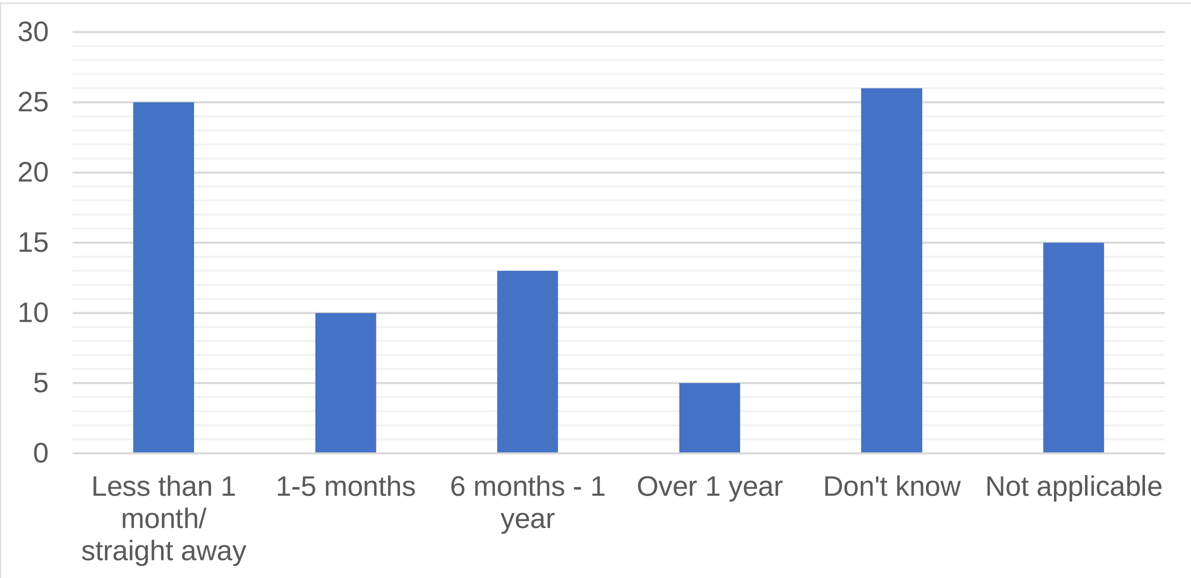
Q19. In your opinion, does your local area have sufficient access to local services and resources that you are able to make use of? (n=87)

39% Yes
61% No
Open text comment box (n=73)

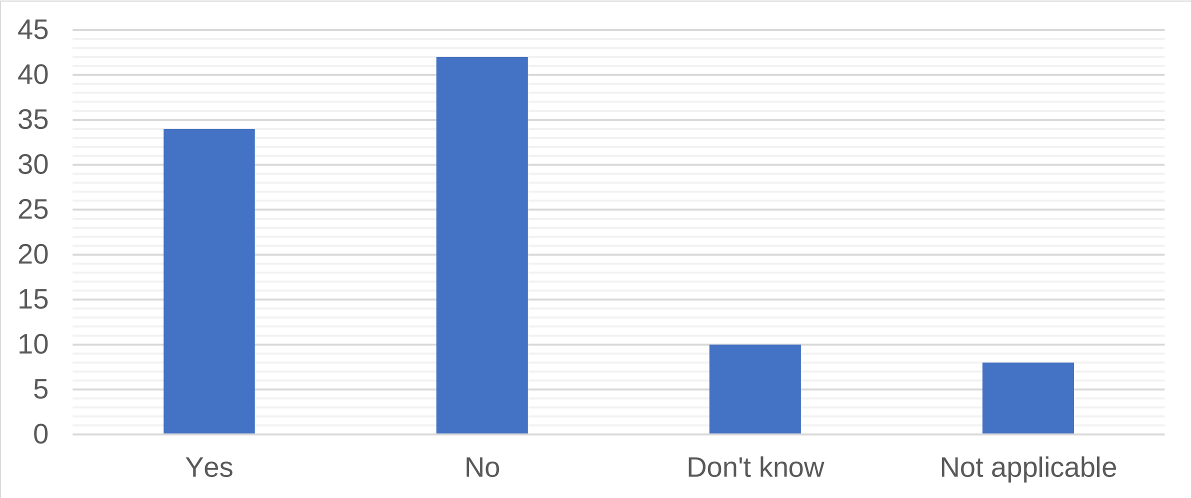
Step 1: Initial coding	Step 2: focussed coding	% answers (step 2)	Step 3: theoretical coding
can't drive, limited mobility, no car, ok as have car	Ok if have private transport	12%	Differing vulnerabilities, distributional justice

irregular, unreliable, insufficient for young people, isolated village	Inadequate public transport	30%	Challenges to building community resilience to coastal change (when lacking or inability to access basic services)
no doctors/ dentist in village	No local healthcare	11%	
long wait times, rising demand, impacted by covid, no gym access, quality has declined, poor hospital access	Inadequate healthcare	16%	
More than one example given	Lack of multiple services	18%	
easy access, adequate no. services, as would expect for village, local or nearby	Sufficient services	23%	Differing vulnerabilities, distributional justice
no post office, no village shop, cinema	Provisions	8%	
lack of funding, rising demand with new developments, villages need investment	More funding/investment needed locally	7%	Recognitional justice
insufficient for young people, only need healthcare from list, don't know	Other	8%	

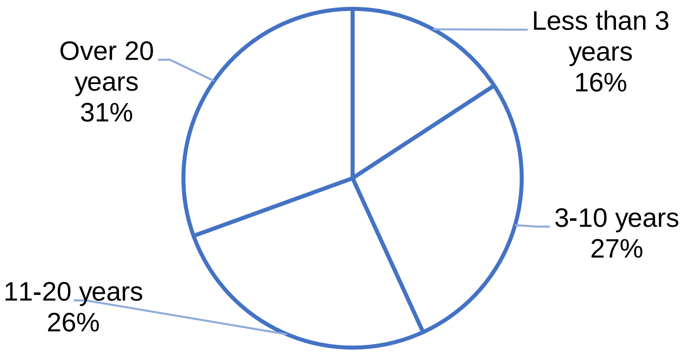
Q20. How long would you be able to withstand financial loss due to coastal erosion or flooding? (n=94)



Q21. In the event of a coastal flood or coastal erosion, do you have a friend or family member who could help you, if your property or village was impacted? (n=94)



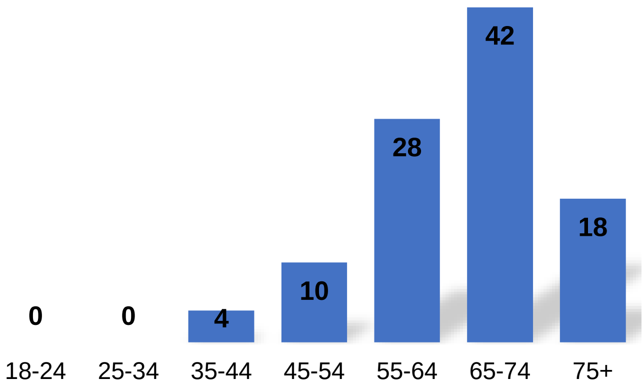
Q22. How long have you lived in Bacton, Walcott or Happisburgh? (n=95)



Q23. Is this your primary residence or a second home? (n=95)

95% ticked primary residence
5% ticked second home

Q24. What age group are you in? (n=102*) (*two surveys were completed by couples)



Appendix 6. Coding framework for interview data

Parent code	Child codes	Code description
1. Perceived effectiveness	**1.1 present day**	Working well / created sand bar / breaking waves / sand will come back Loss of sand / groyne's resurfacing / needs maintaining/topping up to be effective
	1.2 future effectiveness	Not had big storms yet / untested / unsure it will last 20 years/ sand loss rate too fast to last 20 years
	1.3 hard defences	Perceived effectiveness of hard defences / need hard defences to support sandscaping
2. Knowledge *(Capacity to prepare/ adapt, Oriangi et al., 2020)*	**2.1 Lack of knowledge**	Don't know how seas/tides work / not expert /
	2.2 Different 'types' of knowledge	<u>2.2.1 Sources (who/what) of knowledge:</u> Experts, laymen, long-term/ lived experience / passed down knowledge
		<u>2.2.2 Themes/subject of knowledge:</u> Some not wanting 'laymens' to influence coastal decisions vs others not wanting 'experts' to ignore local knowledge. Links to 'community tensions/ divisions' code.
	2.3 Changing knowledge	Increased societal understanding of the risk of climate change (typically that erosion rates are faster than originally thought). Lifetime of houses/ erosion risk at time of buying has changed/ accelerated / not knowing house risk when bought it. Uncertainty around erosion science and risk. Increased knowledge of the need to adapt.
3. Communication *(Capacity to prepare/ adapt, Oriangi et al., 2020)*	**3.1 Communication mis-understandings**	<u>3.1.1 General sandscaping misunderstandings</u> (Beach access and safety, sand martins, wind blown sand) weren't told wind-blown sand would happen / not told when beach access closed / affects tourism/trade
		<u>3.1.2 About beach profile</u> Confusion/ surprise about how beach profile changed post-implementation in 2019, and what was expected. Lack of information on this.
	3.2 Lack of communication about future	Wanting clarity/ certainty of the future fate of one's village / status of village / want to be kept updated about sandscaping / sows doubt / unknown / blight / wanting early planning about future / Politically toxic
	3.3 Source of communication	<u>3.3.1 Mode of communication</u>

		How residents would like to receive information in the future (e.g. leaflets, social media, consultation).
		3.3.2 Independence of communication Importance of independence in information about sandscaping / not biased / evidence-based
		3.3.3 During sandscaping From whom/ sources of information about sandscaping while the scheme was developed
	3.4 Good communication	Anecdotes of good communication about sandscaping scheme or coastal change to residents
4. Trust in policymakers	**4.1 Motive of policymakers**	Scepticism of motive/ Vested interests/ official timeframe / actions / genuine words
	4.2 Strained relations with policymakers	Scepticism of sandscaping due to mistakes of past coastal interventions / strained relations / engagement going nowhere
	4.3 Good relationships with policymakers	Anecdotes of good relations/ experiences between residents and policymakers, good levels of trust
5. Justice *(Different branches of justice, Coolsaet and Neron, 2020)*	**5.1 Procedural justice**	5.1.1 Meaningful consultation Views not listened to / decision made before consultation / consultation pointless / not being valued / not approachable / not considering local voices / also good levels of consultation / good principles of consultation
		5.1.2 Limits of consultation Consultation of limited benefit/ value, local community opinions can be unhelpful / disagreements
		5.1.3 Everybody has a right to know A right to info on how local coast is changing, as it affects livelihoods / Both a right and a choice to be involved
	5.2 Distributional justice	5.2.1 Fairness in where gets protection Differences in levels of protection along coast, differing vulnerability, Happisburgh overlooked by sandscaping / fairness in where get's protection/ funding who pays / who experiences the impact
		5.2.2 Impact of no defences Blight/ low house prices / difficulty selling / community disappearing / cost to demolish homes / can't develop business
		5.2.3 SMP policy injustice/ impact of past policies/ past defences, the right to rollback and loss of right by SMPs, can't withdraw protection without compensation / policymaker comments on financial support
		5.2.4 Unjust decision-making

		Lack of consideration / unequal impacts / overlooked / not prioritised / unfair decision-making
		5.2.5 Impact of policies on coastal risk impact of sandscaping on neighbouring villages/ impact of introducing defences e.g. reefs on neighbouring villages
		5.2.6 Poor implementation of policies / rollback homes not affordable / differences in levels of compensation
	5.3 Capabilities	5.3.1 Witnessing coastal change Speed of loss / unable to process loss or change to surroundings / surreal / sense of loss of buildings gone to sea
		5.3.2 Worry for future of village and livelihoods Despair/ impact of blight/ feeling abandoned / depression / affecting the right to 'a good life' / not being worthy enough of saving / exhaustion /
	5.4 Recognition	Awareness of plight of village by others / Happisburgh no longer being protected is an unknown injustice
	5.5 Inter-generational justice	Impact of coastal risk and climate change on future generations
6. Feeling secure *(Adaptive preference, Bene and Doyen, 2018)* *(Maladaptation, Barnet and O'Neill, 2010)*		Gas terminal too important to be abandoned in future / gas terminal will switch to hydrogen / sea walls will still protect / likely sandscaping will be topped up / villages will be protected / villages seen as 'safe place to buy' / expect houses to be compensated / expect to be helped to move / need more coastal defences, not retreat / hearsay of talk of replenishing sand
7. Perceived responsibility	**7.1 Community responsibility**	7.1.1 Individual level actions Beach cleans & general maintenance, flood wardens, local knowledge, property alterations/ protections, monitoring, giving opinion on consultations, financial donations, Lack of power to influence decisions around coast in village
		7.1.2 Community activism Lobbying / engagement / CCAG / raising awareness / community meetings / pressure group / social media
		7.1.3 What could we do? Not asked before / out of our control / what could we do? (links to 'power' /
		7.1.4 Willingness hard to get locals involved in other local issues besides erosion
	7.2 Policymaker responsibility	The role local residents see policymakers do/ confusion over policymakers managing some aspects of coast but not others / half-in half-out / seen as responsible

8. Bacton Gas Terminal *(Matin et al., 2018; Power and equitable resilience)*		Shell decides what happens next for coast / has the finance and resources/ the true purpose of sandscaping
9. Community	**9.1 Community relations**	<u>9.1.1 Sandscaping disagreements</u> Differing opinions by 'old' vs 'new' residents on coastal management / different opinions on sandscaping's effectiveness /
		<u>9.1.2 Car park disagreements</u> different opinions on relocation of car park at Happisburgh / argument / differing opinions by 'old' vs 'new' residents on coastal management
		<u>9.1.3 General village tensions on coastal change</u> disagreement / tension between individuals / 'elephant in the room' / people don't want to talk about it
		<u>9.1.4 Differences on opinion on future options</u> What coastal management residents perceive should happen in Happisburgh
		<u>9.1.5 Parish councils</u> Arguments /tensions /disagreements between residents and the parish council
	9.2 Changing community	How communities change over time (e.g. rise in second homes, impact of sandscaping/ the pandemic, village becoming more upmarket) / locals vs visitors
	9.3 Sense of community	Perceptions of who / what / strength and sense of community
10. Relations of place	**10.1 Cultural heritage and cultural value**	What's not valued / what's worth saving / Number of listed/ unique buildings / ancient/modern historical significance of village
	10.2 Sense of place	Beauty/ uniqueness of village / village identity village identity under threat if 'emblem's' (i.e. H'bro lighthouse) fall into sea / not wanting to move / deep-rooted / whole village under threat
11. Inevitability		Can't stop the sea /Can't stop erosion entirely/ in long run / what can you do / nothing seems to hold back sea / the physical power of the sea
12. Scalar mismatches *(Capacity to prepare, recover and adapt, Oriangi et al., 2020)* *(Anticipatory vs reactive*	**12.1 Jurisdictional**	Local governance / short-termism / Lack of political priority / Tensions / mismatches central vs local government / different priorities/ need new governance structures / need local community group/ voice set up / more localised decision making / financial resources / adequate funding / the need to mainstream adaptation
	12.2 Spatial	Wanting best for one's village even if it impacts other villages / connected fate of villages through longshore drift. Issue of coastal management nationwide

adaptation, Wolf et al., 2009)	**12.3 Temporal**	Far into future/ Long timescales/ not going to affect them directly / sandscaping will outlive them (or hope it will) / outside their lifetime / Need to proactively plan for retreat and/or adaptation now
13. Environment/ social tensions	**13.1 Climate change**	The impact of climate change on *accelerating* erosion risk / why sandscaping won't last it's expected lifetime
	13.2 Need to consider environment	Impact on sand martins / coastal ecosystems / important to preserve local environment
	13.3 Perceived 'naturalness' of sandscaping	More natural/ kinder to environment / nicer beach scenery / coastscape / should experiment more with nature-based solutions
14. Infrastructural intervention (Deliberate vs forced adaptation, Milhorance et al., 2021)		Reinforce hard defences / introduce new defences / expand/introduce/ top-up soft engineering (top-up sandscaping in '6 feeling secure')
15. Impact of sandscaping		See survey themes – recreational / restorative / mental health / commercial benefits
16. Uncertainty		Impact of not knowing the precise timeline of coastal erosion
17. CTAP		<u>18.1 Language style</u> Clarity / no political spin / difficulty / vagueness of political language / intimidating to engage in it <u>18.2 Perceptions on purpose</u> Residents don't want retreat (yet), need to slow down the rate of erosion
18. Adaptation *(Capacity to prepare, recover and adapt, Oriangi et al., 2020)*		Conversations about adaptation between policymakers and the community / the need to adapt / adaptive capacity / perceptions of adaptation

Appendix 7. Ethics confirmation

Isabel Cotton (DEV - Postgraduate Researcher)
From: Ethics Monitor <no-reply@ethicsreview.uea.ac.uk>
Sent: 02 December 2021 11:44
To: Isabel Cotton (DEV - Postgraduate Researcher)
Subject: Decision - Ethics ETH2122-0192: Miss Isabel Cotton

Study title: Just and resilient adaptation? distributional trade-offs and co-benefits of the Bacton-Walcott sandscaping scheme, Norfolk
Application ID: ETH2122-0192

Dear Isabel,

Your application was considered on 2nd December 2021 by the DEV S-REC (School of International Development Research Ethics Subcommittee).

The decision is: approved.

You are therefore able to start your project subject to any other necessary approvals being given.

This approval will expire on 30th September 2024.

Please note that your project is granted ethics approval only for the length of time identified above. Any extension to a project must obtain ethics approval by the DEV S-REC (School of International Development Research Ethics Subcommittee) before continuing.

It is a requirement of this ethics approval that you should report any adverse events which occur during your project to the DEV S-REC (School of International Development Research Ethics Subcommittee) as soon as possible. An adverse event is one which was not anticipated in the research design, and which could potentially cause risk or harm to the participants or the researcher, or which reveals potential risks in the treatment under evaluation. For research involving animals, it may be the unintended death of an animal after trapping or carrying out a procedure.

Any amendments to your submitted project in terms of design, sample, data collection, focus etc. should be notified to the DEV S-REC (School of International Development Research Ethics Subcommittee) in advance to ensure ethical compliance. If the amendments are substantial a new application may be required.

Approval by the DEV S-REC (School of International Development Research Ethics Subcommittee) should not be taken as evidence that your study is compliant with the UK General Data Protection Regulation (UK GDPR) and the Data Protection Act 2018. If you need guidance on how to make your study UK GDPR compliant, please contact the UEA Data Protection Officer (dataprotection@uea.ac.uk).

I would like to wish you every success with your project.

On behalf of the DEV S-REC (School of International Development Research Ethics Subcommittee)
Yours sincerely,
Teresa Armijos Burneo

Appendix 8. PhD summary (for resident interviewees)

Page 1

Adapting to coastal change

A summary of PhD research on the Bacton-Walcott sandscaping scheme

Isabel Cotton, University of East Anglia (UEA)
i.cotton@uea.ac.uk

Supervisory team: Dr Johanna Forster, Prof Irene Lorenzoni, Dr Trevor Tolhurst (UEA)

Bacton beach (Image: I Cotton)

1 About the research

This PhD project investigated the social and environmental impacts of the Bacton-Walcott sandscaping scheme, and public perceptions of coastal change. The project ran from 2020-2024, and involved:

- A **household survey** to approximately half of residences in Bacton, Walcott and Happisburgh in January 2022 (100 completed surveys, response rate 21%).
- **Interviews** with Bacton (15), Walcott (7) and Happisburgh (8) residents in Autumn 2022.
- **Interviews** with local (2), regional (2) and national (2) coastal policymakers, in early 2023.
- **Analysis of environmental data**, including changes to beach profile, beach volume and cliff rate of retreat at Bacton, Walcott and Happisburgh.

2 Main findings of the research

How has sandscaping changed the coast?

Analysis of environmental data indicates a notable increase in 2019 of the volume of sand at Bacton Gas Terminal and at the villages of Bacton (a 50% increase from 2018) and Walcott (a 77% increase). Since 2019, the volume of sand has been fluctuating year to year. See Figure 1.

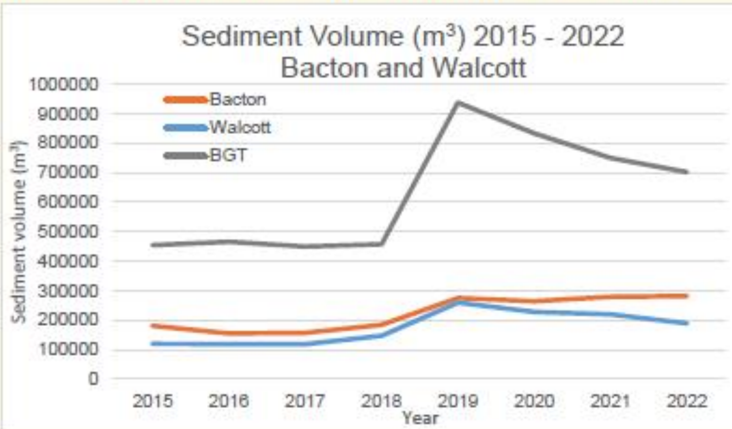


Figure 1. Estimated change in sediment volume (gross, m^3) year to year (2015-2022) at Bacton (orange line) and Walcott (blue line) with respect to Bacton Gas Terminal (BGT, grey line), where the majority of sand was placed for sandscaping in 2019. Volume estimates were calculated from LiDAR data from the Anglian Coastal Monitoring Programme (coastal monitoring.org/anglian/)

What are local residents' views of sandscaping?

Results from the household survey in January 2022 found nearly a third of respondents from Bacton and Walcott explicitly described the scheme as working effectively. But survey responses also showed other views about coastal management and the scheme:

- More than 1 in 4 expressed a preference for hard defences (such as sea walls), or suggested hard defences should also be used alongside sandscaping;
- 23% expressed doubt that sandscaping will last for 15-20 years;
- 16% expressed concern about loss of sand in the first 2-3 years of the scheme and 14% wrote that placed sediment needs 'topping up'.

In addition to the survey results, over half of Bacton and Walcott interviewees articulated some degree of concern that sandscaping would not last for 15-20 years (its official lifetime). This includes interviewees who have strongly positive views of the scheme. Some views were also similar to those in the survey, such as observing a drop in the volume of sand from Bacton and Walcott beaches since 2019.

What does the environmental data show?

Analysis of environmental data of the coast at Bacton and Walcott in the first two years of sandscaping (2020-2021, Figure 2 below) revealed several changes. Reflecting local residents' survey responses, there was a drop in sand on the upper (dry) beach at Bacton and Walcott in 2019-2022 (i.e., first 2-3 years of the scheme). This coincided with an increase in sand in the lower subtidal zone (i.e., below low tide). These changes would not be observable from land.

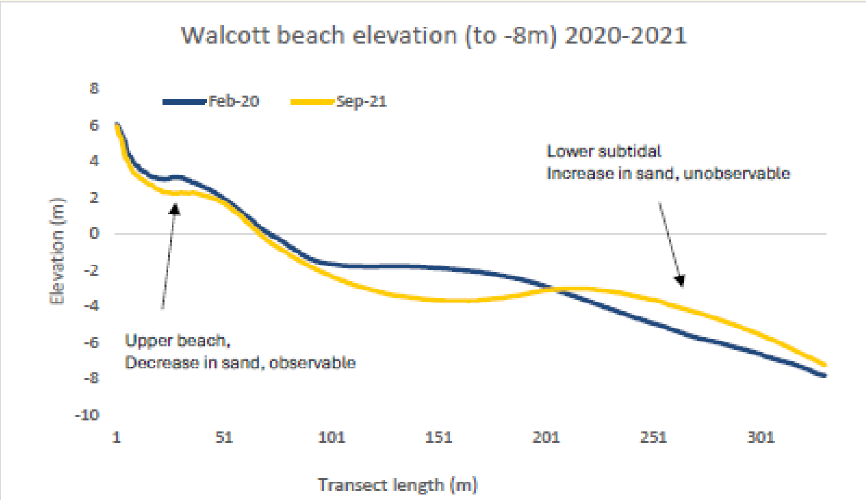


Figure 2. LiDAR data of the Walcott frontage in February 2020 (blue line) and September 2021 (yellow line). This corresponds to the first 1-2 years of the sandscaping scheme. (LiDAR is a type of remote sensing data that produces an elevation profile of the land). Data source: Royal HaskoningDHV © This is copyright material and may not be copied in whole or in part without the express written permission of Royal HaskoningDHV.

UEA University of East Anglia

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What are the social impacts of sandscaping?

Overall, Bacton, Walcott and Happisburgh residents' survey responses reported more positive than negative impacts of the sandscaping scheme. A third of survey answers reported no negative outcomes (see Figure 3). The survey took place in January 2022, over two years since sandscaping was implemented in July 2019.

Reported positive outcomes	Reported negative outcomes
No flooding/ erosion	More people using beach
Bigger/ sandier beach	Impact of more visitors (litter, parking provision)
Recreational opportunities	Wind-blown sand
Improved physical access/ safety getting on/off beach	Change in physical access to beach
Reassurance/ peace of mind	
Increased property value	
Coast road stays open	
More visitors and trade	

Figure 3.

Reported positive (blue shading, left hand side) and negative (orange shading, right hand side) impacts of the sandscaping scheme from residents in the survey. Impacts were not mutually exclusive; respondents reported positive and/or negative impacts, or combinations of these.

Managing coastal risk after sandscaping

- Over three-quarters of Bacton and Walcott residents interviewed described feeling a sense of security from coastal erosion and flooding by living close to Bacton Gas Terminal. The terminal was described as a nationally-important energy infrastructure, that will be protected at any cost.
- At the time the interviews were conducted (2022), many residents perceived that the terminal will only increase in importance for national energy security, due to the cost of living crisis and the war in Ukraine.
- There has been frequent media coverage speculating that Bacton Gas Terminal will be repurposed into a renewable energy plant. At the time of the research, there was no official communication that sandscaping will be repeated in the future.
- All policymaker interviewees expressed the need to prepare now for a future managed realignment policy at Bacton and Walcott.

"I said 'Look. Look out of our window, you've got two aerials there, and you've got Bacton gas site. They are not going to let that drop into the sea, because it supplies a third of the country's gas'. So, as long as that is there, this little house will be fine"
– Bacton resident

"It (sandscaping) was about buying time, and we kind of said it's like turning the clock back. But when we get, we'll get back to a situation where we're going to need to change and adapt. So we need to use this time wisely"
– Local policymaker

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Views on managed realignment

Across all three villages, resident interviewees and survey respondents raised several concerns about a managed realignment coastal policy:

- Managed realignment is perceived by residents as an unjust coastal policy if it is without **financial support** for properties that are lost to erosion;
- All Happisburgh interviewees highlighted the **cultural heritage** or beauty of the village, with many listed buildings that are at risk from erosion;
- 78% of completed surveys from Happisburgh explicitly called for **new or reinstated coastal defences** in open-text survey answers;
- Even amongst Happisburgh interviewees who perceive management realignment in the long-term as inevitable nevertheless feel coastal defences are needed in the short-term, because the rate of erosion is happening too quickly.

"It's frustrating when you're basically told that, you're not worth it, you're not important. There's not enough show. A church founded in 9 something (century) or other isn't important. The lighthouse, the iconic things in all of North Norfolk, no…it's all going to go in the sea"
~ Happisburgh resident

"We need to buy some time, 30-40 years, so that the mechanism by which you move back an ancient village with old buildings, listed buildings, etc can be properly formulated"
~ Happisburgh resident

3 Recommendations

This research project makes several recommendations, the full list of which are summarised in the PhD thesis, and in a PhD summary to coastal policymakers.

<u>When implementing schemes like sandscaping in the future;</u>

- **Explicitly communicate the strengths and weaknesses** of the scheme regarding pre-existing initiatives or strategies and how they may operate differently.
- **Keep local residents updated by publishing monitoring data** about the scheme in an accessible format on a regular basis (e.g. a newsletter or a dedicated website).
- **Explore the role of citizen science in the monitoring of projects.**
- **Provide a dedicated community engagement officer** in the years following implementation. Ring-fence funding for community engagement in the overall budget of the scheme.

<u>Facilitating adaptation at a local level;</u>

- **A designated funding stream for coastal adaptation is needed at a national level,** so that local authorities have the finance and capacity to support communities in at-risk areas that are not defended by coastal protection schemes.
- **A funding stream needs to be matched with clear, practical policy guidance** on how coastal adaptation can be supported at a local level.
- **Policies should include provision for emotional support** as well as the needed financial and practical support. Community engagement needs to offer a compelling future vision for settlements, co-created by communities, that incorporates sense of loss from erosion and flooding impacts and looks forward to fostering resilience.
- **Engaging with local stakeholders beyond traditional routes** (for example pre-established community groups), could be advantageous to widen reach, given that some stakeholders may be reluctant to do so about coastal issues.

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4 Further reading

This is a PhD summary of: I Cotton, 2024. *Examining just and resilient adaptation in light of the Bacton-Walcott sandscaping scheme.* UEA PhD thesis.

The thesis is expected to be available to read from 2025 and stored at the UEA digital repository, which can be accessed here: https://ueaeprints.uea.ac.uk/

Recently published articles from this research can also be accessed here:

- Cotton, I., Forster, J., Lorenzoni, I. and Tolhurst, T.J., 2024. Challenges to anticipatory coastal adaptation for transformative nature-based solutions. *Global Environmental Change*, **88**, Article 102893. Available at: doi.org/10.1016/j.gloenvcha.2024.102893
- Cotton, I., Forster, J., Lorenzoni, I. and Tolhurst, T.J. 2022. Understanding perceived effectiveness of a novel coastal management project: The case of the Bacton-Walcott sandscaping scheme, UK. *Frontiers in Marine Science*, **9**, doi.org/10.3389/fmars.2022.1028819

This PhD research was funded by the Economic and Social Research Council and the Natural Environment Research Council through a SeNSS-ARIES studentship awarded to I. Cotton. The authors would like to thank the Bacton, Walcott and Happisburgh residents who gave their time to contribute to this project by completing the study's public survey and interviews, alongside the coastal policymakers interviewed for this research.

Appendix 9. PhD summary (for policymakers)

Adapting to coastal change

PhD research on the Bacton-Walcott sandscaping scheme

Summary for policymakers

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Supervisory team: Dr Johanna Forster, Prof Irene Lorenzoni, Dr Trevor Tolhurst, UEA

Bacton beach (Image: I Cotton)

About the research

This PhD project based at the University of East Anglia investigated the social and environmental impacts of the Bacton-Walcott sandscaping scheme, and public perceptions of coastal change. Drawing upon data gathered from the local communities of Bacton, Walcott and Happisburgh, alongside analysis of environmental data to investigate coastal changes, the research took place from 2020-2024.

Sand bar on Bacton beach following the sandscaping scheme, Autumn 2022 (Image: I Cotton).

The Bacton-Walcott sandscaping scheme

The Bacton-Walcott coastal management (sandscaping) scheme was implemented in July 2019 to protect the nationally important Bacton Gas Terminal and villages of Bacton and Walcott (in North Norfolk) from coastal erosion and flooding. Sandscaping is an innovative type of sand nourishment that placed 1.8 million m^3 sediment on beaches that will migrate across the coast over time. It is the first time that such large scale one-off sandscaping has been implemented in the UK.

Data collection

- January 2022 – **Household survey** delivered to approximately half of residences in Bacton, Walcott and Happisburgh (100 completed surveys, response rate 21%). The survey asked residents about the impacts of the sandscaping scheme and views of local coastal management strategies.
- Autumn 2022 – **Interviews** with Bacton (15), Walcott (7) and Happisburgh (8) residents. Interviews further explored community perceptions of sandscaping and managing coastal change.
- Early 2023 – **Interviews** with local (2), regional (2) and national (2) policymakers working on coastal change policy across the UK. Interviews discussed coastal adaptation and the Coastal Transition Accelerator Programme, now known locally in Norfolk as Coastwise.
- 2022-2024 – **GIS analysis** of changes to beach profile, beach volume and cliff rate of retreat.

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How has sandscaping changed the coast?

Figure 1 shows the dramatic increase in 2019 of the volume of sand at Bacton Gas Terminal and at the villages of Bacton (a 50% increase from 2018) and Walcott (a 77% increase). Since 2019, the volume of sand has been fluctuating year to year.

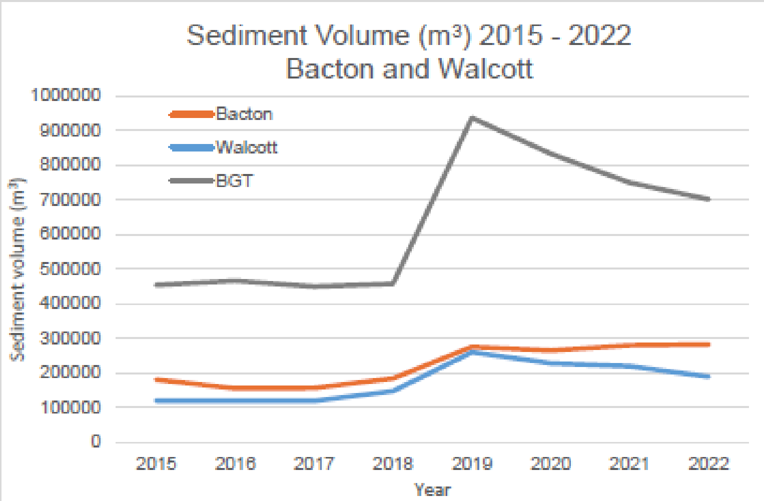

Figure 1. Estimated change in sediment volume (gross, m^3) year to year (2015-2022) at Bacton (orange line) and Walcott (blue line) with respect to Bacton Gas Terminal (BGT, grey line), where the majority of sand was placed from sandscaping in 2019. Volume estimates were calculated from LiDAR data from the Anglian Coastal Monitoring Programme (coastalmonitoring.org/anglian/)

What are the social impacts of the scheme?

Open-text survey questions asking households about any impacts of sandscaping revealed mostly positive answers. A third of survey answers reported no negative outcomes.

Wider social benefits to the scheme beyond flood and erosion protection include **new recreational opportunities** and ways to access a **bigger beach**, **reduced anxiety** about coastal storms, and **increased tourism and trade** for the villages. The latter was viewed unfavourably by some residents in terms of **increased litter, traffic and people** using the beach, alongside the effects of wind-blown sand.

Reported positive outcomes	Reported negative outcomes
No flooding/ erosion	More people using beach
Bigger/ sandier beach	Impact of more visitors (litter, parking provision)
Recreational opportunities	Wind-blown sand
Improved physical access/ safety getting on/off beach	Change in physical access to beach
Reassurance/ peace of mind	
Increased property value	
Coast road stays open	
More visitors and trade	

Figure 2.

Reported positive (blue shading, left hand side) and negative (orange shading, right hand side) impacts of the sandscaping scheme from residents in the survey. Impacts were not mutually exclusive; respondents reported positive and/or negative impacts, or combinations of these.

What are local residents' views of sandscaping?

Results from a household survey in January 2022 found nearly a third of respondents from Bacton and Walcott explicitly described the scheme as working effectively. But survey responses also showed other views about coastal management and the scheme:

- More than 1 in 4 respondents expressed a preference for hard defences or suggested sandscaping should be reinforced with hard defences to provide greater protection from erosion;
- 23% expressed doubt that sandscaping will last for 15-20 years;
- 16% expressed concern about loss of sand in the first 2-3 years of the scheme;
- 14% felt placed sediment needs 'topping up'.

Over half of Bacton and Walcott interviewees (in Autumn 2022) articulated some degree of concern that sandscaping would not last for 15-20 years (its official lifetime). This includes interviewees who have strongly positive views of the scheme. Perceptions include that sandscaping is as of yet untested by extreme weather, and that large amounts of sand have gone from the upper (dry) beach in first few years. All interviewees would like to see more public information about how sandscaping is performing.

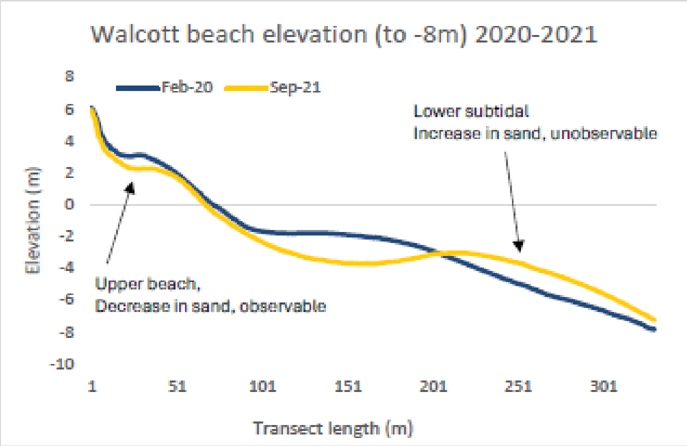

Figure 3. LiDAR (elevation) data of Walcott beach 2020-2021. Environmental data shows there was a drop in sand on the upper (dry) beach at Bacton and Walcott from 2019-2022 (first 2-3 years of the scheme), as local residents described. However, this coincided with an increase in sand in the lower subtidal zone (i.e. below low tide). These changes would not be observable from land.

Policy recommendations:

Introducing nature-based solutions

- **Explicitly communicate the strengths and weaknesses of nature-based solutions** over pre-existing strategies and how they may operate differently to previous policy approaches.
- **Keep local residents updated by publishing monitoring data** about the scheme in an accessible format on a regular basis (e.g. a newsletter or a dedicated website). For example, this could be content similar to Figures 1 and 3 in this document.
- **Explore the role of citizen science in monitoring projects**, which may offer several co-benefits; additional sources of data, community engagement, and increased communication between local authorities and the public.
- **Continue with a dedicated community engagement officer** in the years following implementation. Ring-fence funding for community engagement in the overall budget.
- **Draw upon multiple perspectives in project evaluation**, such as the social impacts or lived experience of affected stakeholders and communities.

Managing coastal risk after sandscaping

- Over three-quarters of Bacton and Walcott residents interviewed described feeling a sense of security from coastal erosion and flooding by living close to Bacton Gas Terminal. The terminal was described as a nationally-important energy infrastructure, that will be protected at any cost.
- To date, there has been no official communication that the sandscaping scheme will be repeated in the future. There has, however, been frequent media coverage speculating that Bacton Gas Terminal will be repurposed into a renewable energy plant.
- At the time the research was conducted (2022), many residents perceive that the terminal will only increase in importance for national energy security, due to the cost of living crisis and the war in Ukraine.

"I said 'Look. Look out of our window, you've got two aerials there, and you've got Bacton gas site. They are not going to let that drop into the sea, because it supplies a third of the country's gas'. So, as long as that is there, this little house will be fine"
– Bacton resident

"It (sandscaping) was about buying time, and we kind of said it's like turning the clock back. But when we get, we'll get back to a situation where we're going to need to change and adapt. So we need to use this time wisely"
– Local policymaker

"People were (saying) 'oh ok, the sand's here, the sea, it's going to last 20 years'...'well, that will see me out. I'd be happy with that'"
– Walcott resident

"Even if it wasn't replenished…then it's still probably another 10-15 years before the seawall would be breached'"
– Walcott resident

All policymaker interviewees expressed the need to prepare now for a future managed realignment policy at Bacton and Walcott. However, interviews with Bacton and Walcott residents revealed:

- A general perception amongst interviewees (across age groups) that any potential property rollback at Bacton and Walcott will be outside their lifetime, regardless of whether sandscaping is repeated;
- A common view that erosion risk would not return immediately post-sandscaping, with some residual life in pre-existing hard defences such as the sea wall. This was a view expressed both by interviewees inland and on the immediate coastal frontage.

Policy recommendations:

Community engagement on coastal adaptation

- **For policymakers, sandscaping has bought time to prepare for managed realignment**, whereas for residents, sandscaping has bought time to postpone it.
- **An intergenerational justice framing** (i.e. the wellbeing of future generations of a community), could be useful for practitioners working in contexts where communities perceive the risk of coastal change as outside their lifetime.
- **Facilitating engagement beyond traditional routes** (for example pre-established community groups), could be advantageous to widen reach, given that some stakeholders may be reluctant to engage.

Views on managed realignment

Across all three villages, resident interviewees and survey respondents raised several concerns about a managed realignment coastal policy:

- Managed realignment is perceived by residents as an unjust coastal policy if it is without **financial support** for properties that are lost to erosion;
- All Happisburgh interviewees highlighted the **cultural heritage** or beauty of the village, with many listed buildings that are at risk from erosion;
- 78% of completed surveys from Happisburgh explicitly called for new or reinstated coastal defences in open-text survey answers;
- Even amongst Happisburgh interviewees who perceive management realignment in the long-term as inevitable nevertheless feel coastal defences are needed in the short-term, because the rate of coastal erosion is happening too quickly.

"It's frustrating when you're basically told that, you're not worth it, you're not important. There's not enough show. A church founded in 9 something (century) or other isn't important. The lighthouse, the iconic things in all of North Norfolk, no…it's all going to go in the sea" – Happisburgh resident

"We need to buy some time, 30-40 years, so that the mechanism by which you move back an ancient village with old buildings, listed buildings, etc can be properly formulated" – Happisburgh resident

This is a PhD summary of: I Cotton, 2024. *Examining just and resilient adaptation in light of the Bacton-Walcott sandscaping scheme*. This is a UEA PhD thesis, expected to be available from 2025 at the UEA digital repository (https://ueaeprints.uea.ac.uk/)

Further reading:

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Policy recommendations:

Facilitating managed realignment at a local level

- **A designated funding stream for coastal adaptation is needed at a national level,** so that local authorities have the finance and capacity to support communities in at-risk areas that are not defended by coastal protection schemes.
- **A funding stream needs to be matched with clear, practical policy guidance** on how coastal adaptation can be supported at a local level.
- **Policies should include provision for emotional support** as well as the needed financial and practical support. Community engagement needs to offer a compelling future vision for settlements, co-created by communities, that works with sense of loss from erosion and flooding impacts, and looks forward to fostering resilience.

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