

7928-2024

Mapping the Governance of Sea Level Changes in Denmark, the Netherlands and the United Kingdom

Report

Norwegian Institute for Water Research

Serial no: 7928-2024

ISBN 978-82-577-7664-0
NIVA report
ISSN 1894-7948

This report has been quality assured according to NIVA's quality system and has been approved by:

Line Johanne Barkved
Project Manager/Lead Author

Sindre Langaas
Quality Assurers

Sindre Langaas
Research Manager

© Norwegian Institute for Water Research and the Norwegian Environment Agency. The publication may be freely quoted with attribution.

www.niva.no

Title	Pages	Date
Mapping the Governance of Sea Level Changes in Denmark, the Netherlands and the United Kingdom Kartlegging av havnivåforvaltningen i Danmark, Nederland og Storbritannia	84 + appendix	17.01.2024
Author(s)	Topic group	Distribution
Line Johanne Barkved, Froukje Maria Platjouw, Paulina Ramírez-Monsalve, Laura Friedrich	Climate	Open
Client(s)	Client's contact person	
Norwegian Environmental Agency	Erlend Moster Knudsen	
Published by NIVA	Client's publication:	
230166	M-2680 2024	

Abstract

This report, commissioned by the Norwegian Environment Agency (NEA), explores and documents the governance of sea level changes in Denmark, the Netherlands and the United Kingdom. These sea level changes consist of the effects of rising sea levels, storm surges, and wave impacts. The aim is to provide Norway with relevant examples and insights. The study maps the governance arrangements of the three countries without directly comparing or evaluating their efforts. It covers how responsibilities are allocated, the use of knowledge tools and databases, financial mechanisms, and overall experiences with the governance of sea level changes in these countries.

Keywords: Sea level changes, sea level governance, climate change adaptation, climate change

Emneord: Havnivåstigning, havnivåforvaltning, klimatilpasning, klimaendringer

Table of Contents

Table of Contents	3
Preface	4
Summary	5
Sammendrag på norsk	6
List of Abbreviations	9
1 Introduction	10
1.1 Adaptation to Sea Level Changes	10
1.2 The Objective of the Report	11
1.3 Briefly about Sea Level Governance in Norway	11
2 Materials and Methods	13
3 Governance of Sea Level Changes in Denmark	14
3.1 Climate Change Adaptation in Denmark	15
3.2 Governance Arrangements for Managing Sea Level Changes	18
3.3 Knowledge Base and Tools for Sea Level Changes	24
3.4 Financial Schemes and Tools Related to Sea Level Changes	30
3.5 Success Stories and Challenges Related to Sea Level Governance	33
4 Governance of Sea Level Changes in the Netherlands	36
4.1 Climate Change Adaptation in the Netherlands	37
4.2 Governance Arrangements for Managing Sea Level Changes	40
4.3 Knowledge Base related to Sea Level Changes	48
4.4 Financial Programs and Tools Related to Sea Level Changes	54
4.5 Success Stories and Challenges related to Sea level Governance	56
5 Governance of Sea Level Changes in the United Kingdom	61
5.1 Climate Change Adaptation in the UK	61
5.2 Governance Arrangements for Managing Sea Level changes	63
5.3 Knowledge Base and Tools for Sea Level Changes	72
5.4 Financial Programs Related to Sea Level Changes	76
5.5 Success Stories and Challenges related to Sea Level Governance	76
6 Synthesizing Governance of Sea Level Changes in in Denmark, the Netherlands and the United Kingdom	78
7 References	82
Appendix	85

Preface

The project “Mapping the Governance of Sea Level Changes in Denmark, the Netherlands and the United Kingdom” was initiated by the Norwegian Environment Agency (NEA) and carried out by the Norwegian Institute for Water Research (NIVA) between September 2023 and January 2024. The project addresses the governance of sea level changes, including sea level rise, storm surges and wave impacts, all of which are critical issues for coastal countries. The report documents sea level governance practices in Denmark, the Netherlands and the United Kingdom (UK), aimed at providing relevant insights and examples for Norway.

The team at NIVA has consisted of researchers in climate adaptation and policy research: Froukje Maria Platjouw, Paulina Ramírez-Monsalve, Laura Friedrich and project manager Line Johanne Barkved. The mapping of the three countries was split among the team with Platjouw focusing on the Netherlands, Ramirez-Monsalve on Denmark and Friedrich on the UK, and with the project manager Barkved contributing to the mapping efforts in each country and having overall responsibility for the study. Furthermore, Isabel Seifert Dähnn has contributed with advice related to financial aspects, as well as overall inputs and comments to the report.

Contact persons at the Norwegian Environment Agency (NEA) were Erlend Moster Knudsen and Ida Marie Gildestad. The guidance provided along the way by the NEA was helpful in ensuring that the report was aligned with the assignment’s objectives and the desired themes to be covered.

We express our sincere thanks to the informants from the three study countries who contributed valuable insights and feedback to the report, enhancing the depth and relevance of the findings. Acknowledgements for Denmark include: Kaija Jumppanen Andersen from the Danish Coastal Authority, Associate Professor Lars Bodum, the Department of Sustainability and Planning at Aalborg University, as well as one representative from the Danish Environmental Protection Agency and two informants from the National Association of Municipalities. For the Netherlands: Marjolijn Haasnoot, Researcher climate change adaptation and water management at Deltares and Professor at Utrecht University, Dick Boland, Advisor climate adaptation advisor at Rijkswaterstaat, as well as one representative from the Dutch Ministry of Infrastructure and Water Management. For the UK: Andrew Eden, Flood and Coastal Risk Manager/ Programme Leader Adaptation and Resilience, Stuart Allen Principal Scientist, Climate Change and Resource Efficiency, Chief Scientist Group and Andy Beverton Research Scientist, Climate Change and Resource Efficiency, Chief Scientist Group with the UK Environment Agency, as well as Leslie Mabon, lecturer in Environmental Systems at the Open University. Nevertheless, the responsibility for the content of this report, including any errors or misinterpretations, lies with us, the authors at NIVA.

Oslo, 12.01.2024

Summary

Climate change adaptation to sea level changes, composed of sea level rise, storm surges and wave impacts, is a multifaceted and critical issue for coastal nations worldwide. Understanding how authorities and actors in other countries work to adapt to sea level changes, may provide useful insight into how Norway can improve its own governance of sea level rise and related phenomena.

This report, commissioned by the Norwegian Environment Agency (NEA), seeks to provide an overview of and insights into how Denmark, the Netherlands and the United Kingdom (UK) are navigating and governing sea level changes. The report maps governance arrangements and brings forward relevant examples and experiences for different aspects of sea level governance in countries with which Norway can compare itself. The report addresses how responsibilities are distributed, what knowledge tools and databases are used, what financial mechanisms exist and overall experiences that Norway might learn from related to governance of sea level changes.

In all three countries, various actors work with strategies, knowledge tools, and financing schemes to better plan for and adapt to sea level changes. Denmark's strategy is focused on integrated coastal management, emphasizing local community involvement and decentralized decision-making. The Netherlands presents a contrasting picture with a more centralized governance model and emphasis on adaptive pathways planning, with prominent roles of the national executive agency of the Ministry of Infrastructure and Water Management, Rijkswaterstaat, and the Delta Programme and Commissioner. The UK integrates regional adaptation plans with comprehensive national strategies and puts much emphasis on research and public awareness. The UK government launched its third National Climate Adaptation Programme (NAP3) in June 2023. This strategic 5-year adaptation plan includes responses to rising sea levels and extreme weather. In Denmark and the Netherlands, initiatives and knowledge programmes specifically related to coastal challenges provide interactive tools and climate impact atlases to support planning and risk assessment in line with current and upcoming National Climate Adaptation Plans.

Denmark, the Netherlands and the United Kingdom (UK) all face the challenge of upgrading and maintaining infrastructure to withstand increased risks related to sea level changes. Though the countries differ in their approaches, key common themes emerging from all three countries are cross-sector collaboration, adaptive governance and responsiveness to new challenges and scientific advancements in sea level rise, storm surges and wave impacts. Governance of sea level changes is a comprehensive field of governance in all three countries, touching upon an evolving scientific knowledge base, multiple sectors and policy areas involved, and ethical choices to be made. Deciding which climate change scenarios to use, determining which risks are considered socially acceptable, and identifying how to collectively fund the substantial financial resources needed to adapt to sea level changes present common challenges. Informants in all three countries emphasize the importance of enhancing stakeholder engagement and public awareness for successful governance, particularly in including various actors in decision-making and improving public understanding of the risks and necessary adaptations related to sea level changes.

While direct recommendations are outside this report's scope, the experiences from Denmark, the Netherlands, and the UK may provide valuable insights and potential approaches for Norway as it continues to develop its sea level governance framework.

Sammendrag

Klimatilpasning til havnivåendringer, i form av havnivåstigning, stormflo og bølgepåvirkning, er en kompleks og økende problemstilling for kystnasjoner over hele verden. Klimaendringer fører til at havnivået stiger i stadig raskere tempo, og ifølge IPCC vil havnivåstigning bli en av de store klimautfordringene fremover. Sammen med stormflo og bølger ved kraftig lavtryksaktivitet gir havnivåstigning økende utfordringer også langs norskekysten. Samlet styrker disse endringene behovet for klimatilpasning. I dette ligger også et behov for å ha oversikt over hvilke plikter og krav som stilles til kommunene og andre sentrale aktører gjennom regelverket, tilhørende retningslinjer og veiledninger, og å ha kjennskap til øvrige nasjonale føringer og virkemidler på området. Innsikt i hvordan myndigheter og aktører i ulike land organiserer arbeidet for å tilpasse seg havnivåendringer, kan bidra med nyttig informasjon til hvordan Norge kan videreutvikle sin havnivåforvaltning.

På oppdrag for Miljødirektoratet har NIVA kartlagt havnivåforvaltningen i tre land som Norge kan sammenligne seg med, henholdsvis Danmark, Nederland og Storbritannia. Miljødirektoratet koordinerer det nasjonale klimatilpasningsarbeidet i Norge og er bestiller av det norske kunnskapsgrunnlaget innen havnivåstigning, stormflo og bølgepåvirkning. Riksrevisjonen vurderte i 2021-22 norske myndigheters arbeid med å tilpasse infrastruktur og bebyggelse til et klima i endring. De konkluderte bl.a. at norske kommuner ikke får tilstrekkelig faglig bistand til å håndtere oppgaver knyttet til havnivåstigning, stormflo og bølgepåvirkning. Som en oppfølging på Riksrevisjonens konklusjon ønsket Miljødirektoratet å få laget en oversikt over forvaltningen av disse problemstillingene i de tre landene.

Rapporten er en kartlegging og sammenstilling av nøkkelaspekter og eksempler fra Danmark, Nederland og Storbritannia knyttet til hvordan de er organisert og jobber med klimatilpasning til havnivåendringer. For Storbritannia, der organisering og ansvar skiller seg noe mellom England, Wales, Skottland og Nord-Irland, har vi i hovedsak sett på England eller på aspekter gjeldende for hele Storbritannia. Metodene brukt har inkludert dokumentanalyse, gjennomgang av nettsteder og intervjuer med eksperter fra de tre landene. Funnene av kartleggingen presenteres i egne landspesifikke kapitler og rapporten avsluttes med en sammenfatning av de overordnede funnene for de tre landene. Oppdraget har ikke omfattet å utføre evalueringer av de enkelte landenes havnivåforvaltning eller å gjøre en sammenlignende analyse.

I alle de tre landene arbeider ansvarlige myndigheter med strategier, kunnskapsverktøy og finansieringsordninger for bedre å kunne planlegge og tilpasse seg havnivåendringer. I arbeidet har det blitt tydelig at dette er et dynamisk forvaltningsområde. Flere av informantene har beskrevet kunnskapsgrunnlag, veiledninger og planer som er under oppdatering og utvikling for å ferdigstilles i 2024 eller de påfølgende årene. Eksempelvis, arbeides det i alle landene med å bestemme hvilke klimascenarier basert på IPCCs siste globale rapport som skal legges til grunn i de videre føringer og arbeid knyttet til klimatilpasning til havnivåendringer. I så måte vektlegger rapporten noen aspekter særlig aktuelle i de undersøkte land akkurat nå.

Danmarks havnivåforvaltning har en desentralisert tilnærming, hvor det lokale nivået og kommunene har et stort ansvar. Siden 2018 har kystbeskyttelsesloven blitt forvaltet av kommunene. Danmark har særlig fokus på integrert kystforvaltning med klimatilpasning til stormflo og kysterosjon, med vekt på involvering av lokalsamfunn. Sentrale nasjonale myndigheter er Miljøministeriet og det tilhørende Kystdirektoratet. Kystdirektoratet utvikler bl.a. nasjonale risikovurderinger for kystoversvømmelser- og erosjon, for ulike tidshorisonter, i samarbeid med, og basert på, klimascenarier utviklet av Danmarks Meteorologiske

Institutt (DMI). Kommuner og private grunneiere er sentrale i forvaltningen av havnivåendringer, ettersom det ifølge Kystbeskyttelsesloven er de som nytter godt av tilpasningstiltak som i hovedsak skal dekke kostnadene ved kystbeskyttelse og klimatilpasning. I oktober 2023 la den danske regjeringen fram forslaget til en nasjonal klimatilpasningsplan (klimatilpasningsplan 1). En tydelig ambisjon er at det skal gjøres mer for å beskytte kysten, byer, boliger og infrastruktur mot konsekvensene av klimaendringene og den nye planen skal hjelpe kommuner og grunneiere med dette. Kystdirektoratet støtter kommunene i dette arbeidet ved å blant annet legge til rette kunnskapsgrunnlag om kystrisiko og å bidra med veiledning. Det finnes også midlertidige finansielle støtteordninger som kystkommuner kan søke på for såkalte fellesprosjekter for å gjøre klimatilpasningstiltak langs kysten. Disse er med den nye planen blitt forlenget også ut 2024. Videre er det også en stormflokompensasjonsordning tilgjengelig for private for å dekke skader ved stormflo (av en viss størrelse). Dette administreres gjennom forsikringsselskapene, men forvaltes av et uavhengig råd, Naturskaderrådet, som bestemmer hvorvidt en bestemt stormflohendelse skal dekkes av ordningen.

Nederland har en mer sentralisert styringsmodell for havnivåforvaltningen, hvor nasjonale myndigheter har mye ansvar og det legges vekt på planlegging av såkalte tilpasningsalternativer (*adaptive pathways planning*). I den nederlandske tilnærmingen legges det stor vekt på å ha holde ulike forvaltningsalternativer åpne. De ulike tilpasningsveiene, som alle er i tråd med lovfestet akseptabel samfunnsrisiko (gitt som en dødelighet på 1:100 000), påvirker havnivåforvaltning og samfunnet forskjellig. For å kunne tilpasse seg til ny og oppdatert vitenskapelig kunnskap i fremtiden, er det lagt til rette for å enkelt kunne skifte mellom de utformede tilpasningsveier. Rijkswaterstaat, det operative nasjonale forvaltningsorganet til departementet for infrastruktur og vannforvaltning, og Deltakommissaris og Deltaprogrammet, har sentrale roller i forvaltningen. Deltakommissaris er en politisk uavhengig aktør som sikrer langsiktig planlegging for havnivåforvaltning. Regionale aktører, som for eksempel regionale vannmyndigheter, spiller også en viktig rolle for gjennomføringen og implementeringen av de nasjonale planene og strategiene, og for å sikre at eksisterende infrastruktur for å beskytte landet mot et stigende havnivå er klimarobust. Styringsprinsippene omfatter en risiko-basert og adaptiv tilnærming og et solidaritetsprinsipp for finansiering av tiltak som betyr at alle er med å finansiere klimatilpasningstiltakene til havnivåendringer gjennom skatteordninger. Kunnskapsgrunnlaget er omfattende med prognoser frem til år 2300 fra det nederlandske meteorologiske instituttets (KNMI) kunnskapsprogram om havnivåstigning. Samarbeid mellom ulike sentrale og regionale aktører og kunnskapsleverandører (Deltares og universiteter) er sterkt forankret i Nederland gjennom en rekke mekanismer. Et eksempel på dette er den årlige Delta Kongressen hvor ny kunnskap formidles og den årlige Deltaplanen presenteres.

I Storbritannia er havnivåforvaltning både desentralisert og delegert, og kjennetegnes dermed av en flernivåstrukturert forvaltningstilnærming. Departementet for Miljø, Mat og Bygdesaker (DEFRA) spiller en sentral rolle i å fremme politikk og reguleringer på nasjonalt nivå. Disse reguleringene implementeres på regionalt og lokalt nivå. Havnivåforvaltningen er særlig styrt av den nasjonale strategien for flom og kysterosjon (*Flood and Coastal Erosion Risk Management Strategy*). En sentral aktør i gjennomføringen av denne strategien er miljødirektoratet (Environment Agency) i England og tilsvarende byråer i Skottland, Wales og Nord-Irland. Disse direktoratene er sentrale i strategisk risikostyring og gir viktig veiledning for lokal planlegging i områder med flomrisiko og kysterosjon. Arbeidet er forankret i Klimaloven 2008 (*Climate Change Act 2008*), som sier at klimaendringene skal vurderes jevnlig og dynamiske nasjonale tilpasningsprogrammer (NAP) utvikles. Disse programmene oppdateres kontinuerlig med det siste tilgjengelige vitenskapelige kunnskapsgrunnlag og klimaprognoser, som utvikles av bl.a. Met Office Hadley Center, det ledende forskningscenter i Storbritannia på klimaendringer. Den britiske regjeringen

lanserte nylig sitt tredje nasjonale klimatilpasningsprogram (NAP3) i juni 2023, hvor denne strategiske femårsplanen for klimatilpasning omfatter tiltak mot havnivåstigning og ekstremvær. Vitenskapelige klimascenarier som utarbeides og oppdateres ved jevne mellomrom, legges til grunn for utformingen av den nasjonale strategien. Disse scenarier, som for eksempel UK Climate Projections 2018 (UKCP18), strekker seg til 2100. Det legges også vekt på å utvikle kunnskapsgrunnlaget gjennom forskning, som f.eks. utviklingen av havnivåscenarier for 2300 og bevisstgjøring av befolkningen knyttet til havnivåendringer. Forvaltningstilnærmingen kjennetegnes videre av en risikobasert tilnærming og en stegvis planlegging for implementering. De lokale kystforvaltningsmyndighetene er ansvarlige for å forvalte flom- og erosjonsrisikoen ved kysten, og benytter en risikobasert tilnærming i sine planleggings- og beslutningsprosesser. De ulike strategiene er beskrevet i såkalte strandlinjeforvaltningsplaner (*shoreline management plans*). Tilnærmingen omfatter en rekke strategier, for eksempel "beholde kystlinjen", "kontrollert justering" eller "ingen aktiv inngripen". Finansieringen av planer og prosjekttiltak på lokalt nivå skjer gjennom statlige initiativer, som for eksempel investeringsprogrammet for håndtering av flom og erosjonsrisiko (*Flood and Coastal Erosion Risk Management Investment Programme*).

Forvaltning av havnivåendringer er et omfattende forvaltningsområde i alle de tre landene, med et vitenskapelig kunnskapsgrunnlag i stadig utvikling, mange involverte sektorer og politikkområder og etiske valg som må tas. Selv om landene har ulike tilnærminger, er samarbeid på tvers av sektorer, tilpasningsdyktighet og evne til å respondere på nye utfordringer og kunnskapsunderlag knyttet til havnivåstigning, stormflo og bølgepåvirkning sentrale temaer i alle de tre landene. Det arbeides i alle landene med å avgjøre hvilke klimascenarier som skal brukes, hvilke risikonivå som kan anses som sosialt akseptable, og hvordan man samlet skal finansiere de betydelige økonomiske ressursene som trengs for å tilpasse seg havnivåendringene. Informanter i alle de tre landene understreker at det er viktig å styrke ulike aktørers engasjement og bevisstheten blant befolkningen for å lykkes med forvaltningen, særlig når det gjelder å inkludere ulike aktører i beslutningsprosesser og øke befolkningens forståelse av risiko og de nødvendige tilpasningene som må gjøres til havnivåendringene, på kort og på lengre sikt.

List of Abbreviations

Abbreviation	Full form
CBG	Centre for Blue Governance
CCRA	Climate Change Risk Assessment (in the UK)
CMIP	Coupled Model Intercomparison Project
DCA	Danish Coastal Authority
DAERA	Department of Agriculture, Environment and Rural Affairs in Northern Ireland
DEPA	Danish Environmental Protection Agency (<i>Miljøstyrelsen</i>)
Dfi	Department for Infrastructure in Northern Ireland
DNA	Danish Nature Agency (<i>Naturstyrelsen</i>)
DMI	Danish Meteorological Institute (<i>Danmarks Meteorologiske Institut</i>)
DSB	Norwegian Directorate for Civil Protection (<i>Direktoratet for samfunnsikkerhet og beredskap</i>)
Defra	Department for Environment, Food and Rural Affairs (in the UK)
FCERM	Flood and Coastal Erosion Risk Management
FD	EU Floods Directive
GIS	Geographic Information Systems
HWBP	Flood Protection Programme (<i>Hoogwaterbeschermingsprogramma</i>)
IPCC	Intergovernmental Panel on Climate Change
IPCC AR5	Intergovernmental Panel on Climate Change Fifth Assessment Report
IPCC AR6	Intergovernmental Panel on Climate Change Sixth Assessment Report
KNMI	Royal Netherlands Meteorological Institute (<i>Koninklijk Nederlands Meteorologisch Instituut</i>)
LIWO	National information system water and flooding
MSFD	Marine Strategy Framework Directive
MSPD	Maritime Spatial Planning Framework Directive
NAP(s)	National Adaptation Programme(s)
NAS	National Adaptation Strategy
NEA	Norwegian Environment Agency (<i>Miljødirektoratet</i>)
NICCAP	Northern Ireland Climate Change Adaptation Programme
NWP	National Water Programme
OGA	Office of the Audit General of Norway (<i>Riksrevisjonen</i>)
PBL	Dutch Environment Agency (<i>Planbureau voor de Leefomgeving</i>)
RCP	Representative Concentration Pathway
RWS	Rijkswaterstaat
SCCAP	Scottish Climate Change Adaptation Programme
SEPA	Scottish Environment Protection Agency
SIG	Special Interest Group
SLR	Sea Level Rise
UK	United Kingdom
UKCP	UK Climate Projections (UKCP09, UKCP18)
WFD	EU Water Framework Directive

1 Introduction

Climate change poses significant challenges that require adaptation across many areas. Sea level rise due to climate change has been accelerating over the last decades, making coastal communities around the world vulnerable to flooding and erosion (Oppenheimer et al., 2019). **Sea level changes**, here defined as sea level rise, storm surges and wave impacts (individually or in combination), affect infrastructure, settlements, agricultural lands, natural values and cultural environments in coastal countries. This report concerns **the governance of sea level changes** in three coastal countries: **Denmark, the Netherlands and the United Kingdom (UK)**.

The report has been commissioned by the Norwegian Environment Agency (NEA). Norway has a long coast and is therefore vulnerable to sea level changes. Furthermore, recent evaluations by the Office of the Audit General of Norway (OAG) related to climate change adaptation found that the municipalities do not receive sufficient knowledge-related and technical assistance from national authorities to be able to fulfil the significant task they are required to handle related to sea level changes (OAG, 2022). With climate change poised to intensify these challenges, the roles of various government agencies, including the Norwegian Environment Agency (NEA), become increasingly important.

This report responds to the NEA's call to map the governance structures and experiences in Denmark, the Netherlands and the UK, with the aim to learn and get inspiration from countries that are comparable to Norway. The focus of the study has been on understanding the governance frameworks, policy tools and distribution of responsibilities among different national and local authorities concerning sea level changes in the three countries.

1.1 Adaptation to Sea Level Changes

In line with the white paper on climate adaptation Meld. St. 26 (2022–2023), we define climate adaptation as "understanding the consequences of climate change and implementing measures to prevent or reduce damage on one hand and to exploit the opportunities that changes may entail" (Norwegian Ministry of Climate and Environment, 2022–2023, p. 6).

The report focuses on the **governance aspects related to sea level changes**. Sea level changes encompass sea level rise, storm surges, and wave impacts. Sea level rise refers to the gradual increase in the average level of the world's oceans, whereas storm surges are temporary but extreme rises in sea level caused by intense storms, exacerbating coastal flooding risks. Wave impacts involve the force and effects of waves on coastlines, which can lead to erosion and alter coastal landscapes. Together, these phenomena pose significant challenges to coastal regions.

Furthermore, we understand **governance** as the "formal and informal processes of collective decision-making, planning, deliberating, and capacity building by governmental, market, and civil society actors" (CBG, n.d).¹ In the report, the terms **governance of sea level changes** and, in short, **sea level governance** are used interchangeably.

As sea levels will continue to rise over the next centuries to millennia due to climate change (Oppenheimer et al., 2019), the need to develop robust adaptation strategies becomes increasingly

¹ CBG (n.d). Centre for Blue Governance <https://www.en.plan.aau.dk/research/centre-for-blue-governance> (accessed 02.11.2023)

urgent. Sea level rise, driven by factors such as melting ice caps and thermal expansion of the oceans, threatens coastal ecosystems, infrastructure and communities. In addition to the gradual rise of sea levels, the increasing frequency and severity of storm surges and wave impacts compound the challenge, exacerbating the risk to coastal regions.

Adapting to these changes is a multifaceted task that requires balancing the protection of existing structures and future land use planning while continuously updating the scientific and local knowledge base. Furthermore, as sea level changes have socio-economic impacts, environmentally sustainable and socially equitable strategies are needed.

1.2 The Objective of the Report

In this report, we explore how Denmark, the Netherlands and the United Kingdom are addressing sea level changes through their governance structures and adaptation policies. Our focus extends beyond their practical approaches, including how they build and utilize the necessary knowledge base for effective adaptation to long-term sea level rise and more short-term impacts of storm surges and waves.

The report is not a comparative analysis of the three countries but rather a mapping of governance structures and first hand experiences from authority representatives in the three countries that Norway can compare itself to. This study aims to contribute to the NEA's initiative to enhance the knowledge base related to sea level changes along the Norwegian coast and to strengthen the understanding and response to these changes.

The objectives are two-fold: firstly, to map the governance and responses to sea level changes in the three countries, and secondly, to gather and analyse experiences from the countries in managing such changes. The mapping includes describing the governance models, including the coordination between different levels of government and examining how local authorities are supported and involved in these efforts.

As part of the organizational aspects, we describe the legal, financial and information tools used by the countries in addressing sea level changes. This includes how sea level changes and risks are integrated into national regulations and local planning, the financing mechanisms in place, and available support tools and databases. An essential aspect of the mapping is a forward-looking approach, considering what strategies and principles the three countries are choosing to prepare for future changes.

1.3 Briefly about Sea Level Governance in Norway

According to the white paper on climate adaptation from the Norwegian Ministry of Climate and Environment on climate adaptation, Meld. St. 26 (2022–2023), local, regional, and national authorities must consider sea levels changes in their governance, which necessitates good coordination among the national government bodies. Such coordination is considered vital to ensure comprehensive consideration of sea level changes across affected areas and coherent national action and guidance towards local and regional authorities (OAG, 2022).

In Norway, the Ministry of Climate and Environment is responsible for the government's overall work on climate change adaptation and coordinates the work between the ministries. The Norwegian Environment Agency (NEA) is the agency that supports the Ministry in its work on adaptation and is responsible for coordinating the national work on climate change adaptation. In close cooperation with other relevant directorates, the NEA supports actors at local, regional and national level to adapt to climate change.

Key governing principles in Norway related to climate change adaptation (as noted in Meld. St. 26 (2022–2023)) are the **principle of responsibility** (*ansvarsprinsippet*), stating that the responsibility for climate change adaptation lies with those who are responsible for a task or function that is affected by climate change. This means that everyone in the society has a responsibility for climate change adaptation - public authorities, businesses and private individuals. For public authorities, the **sectoral responsibility** (*sektoransvaret*) applies, which means that all sectoral authorities must have an overview of risks, both direct and indirect, related to climate change within their sectoral areas and assess the need for efforts and measures to manage the risk. The **precautionary principle** (*føre-var-prinsippet*) entails that high alternatives from the national climate projections should be used as a starting point when assessing the impact of changing climate. In each individual case, the emphasis on climate change considerations must be balanced against other important social considerations.

In Norway, various government agencies share responsibility for supporting municipalities in adapting to sea level changes. These include the Norwegian Directorate for Civil Protection, the Norwegian Mapping Authority, the Norwegian Environment Agency (NEA) and the County Governor.

NEA is responsible for coordinating and providing guidance to the Ministry of Climate and Environment on what projections for sea level rise that should be used as a basis for planning throughout Norway. Involving relevant national governmental bodies, the NEA must update these projections and guidance regularly in accordance with the assessment reports by the Intergovernmental Panel on Climate Change (IPCC). Currently, the Norwegian Centre for Climate Services, involving the Norwegian Mapping Authority, NORCE Norwegian Research Centre, the Norwegian Meteorological Institute and the Nansen Environmental and Remote Sensing Center, updates the projections for sea level rise along the Norwegian coast based on the Sixth Assessment Report (AR6) of the IPCC. This work is commissioned by NEA and involves other relevant stakeholders.

Despite the efforts made in integrating the consideration of sea level rise and storm surges, especially in areas like social security, there remain variations in how different sectors incorporate these aspects into their responsibilities. During 2021-22, the Office of the Audit General of Norway (OAG) conducted a survey on Norwegian authorities' work to adapt infrastructure and buildings to climate change. Its evaluation found that the national government provides municipalities with inadequate assistance related to sea level rise, storm surges and wave impacts (i.e. sea level changes) (OGA, 2022, p.23).

In response to these challenges, the Norwegian government has emphasized the need for greater coordination at the national level (Meld. St. 26 (2022–2023)). In its role as the coordinating agency for climate adaptation, the NEA is tasked with driving efforts across different actors to enhance Norway's preparedness and response to climate change, including the rising challenges posed by sea level changes.

2 Materials and Methods

This report covers the governance of sea level changes in Denmark, the Netherlands and the UK, that we in short will refer to as sea level governance. Under sea level governance, we include the governance of sea level rise, storm surges and wave impacts. As mentioned in the introduction, we understand governance as “the formal and informal processes of collective decision-making, planning, deliberating, and capacity building by governmental, market, and civil society actors” (CBG, n.d).²

The key guiding questions for this report were:

1. What are the key actors, their roles and responsibilities (i.e. what requirements for sea level governance are there) at the different governance/planning levels?
2. What are the guidelines and requirements related to sea level change in government policies, strategies, guidance documents and legislation?
3. What are the key knowledge bases and tools for addressing sea level changes, and what time horizons and scenarios are used?
4. What are the key financial tools and mechanisms for addressing sea level changes?

The first step in the study was to map how Denmark, the Netherlands and the UK have structured their sea level governance. The mapping was conducted between September 2023 and January 2024 through a document analysis combined with interviews with relevant informants from the three countries. We sourced pertinent documents from government websites on climate adaptation, sea level and coastal protection, and 'climate adaptation portals' in the respective countries, supplemented by web searches and references and documents obtained through contacts with relevant actors. This initial mapping and document collection formed the foundation for our subsequent interviews and analysis.

The digital interviews with sea level governance officials and experts in the three countries aimed to ensure that we had retrieved the relevant and most up-to-date information and to capture relevant nuances and experiences. The questions asked during the interviews were tailored based on the country and the informant's role (see Appendix A for an overview of interviews). The information from these interviews, along with the data obtained from the document analysis, was then processed and compiled in accordance with the report's objectives. Some of the information has been studied in the countries' local languages and translated into English for the report (see Appendix B for key terms). Drafts of the report's country chapters were also shared with informants from the respective countries for feedback. This approach has enabled an overall understanding of the governance strategies and aspects, as presented in the country-specific chapters (Chapters 3, 4, and 5) and the synthesis (Chapter 6).

As mentioned in the introduction, the objective of the mapping was not to conduct a comprehensive evaluation or comparative study of the countries' sea level governance. Therefore, the presented material and examples may not cover all details or the same level of detail for each country, also reflecting differences in their sea level governance approaches. Furthermore, the dynamic nature of adapting to sea level rise, storm surges and wave impacts should be acknowledged. During the preparation of this report, all the three countries were in the process of developing new updated knowledge reports and guidance materials. Consequently, this report represents a snapshot of an evolving field, capturing the situation at a specific point in time, with the understanding that the situation is continuously advancing and changing.

² Centre for Blue Governance (CBG): <https://www.en.plan.aau.dk/research/centre-for-blue-governance> (accessed 02.11.2023)

3 Governance of Sea Level Changes in Denmark

Denmark consists of the Jutland peninsula and more than 400 islands of which Zealand and Funen are the largest ones. It is a lowland country, with the highest hill being approximately 170 meters above sea level. The Danish coastline is over 8,000 km long. It includes active coastal cliffs and non-cliff areas where the sea erodes material and partly beach-ridge complexes where the material is deposited in the lee of prevailing winds. The central part of the west coast of Jutland is a sandy beach with (by now artificial) dunes and low-lying land behind. The Danish coastline also includes cliffs that do not erode (southern part of Zealand) as they consist of limestone. These characteristics – a lowland country, with a long coastline and many islands - make Denmark vulnerable to seawater and groundwater rise as a result of climate change.³

While sea level rise will cause regular flooding from the sea and coastal erosion both in low-lying coastal areas and cliffs, the impacts of storm surges depend on wind direction and pressure. In the future, it is expected that it predominantly will be the extreme events rather than the gradual rise in sea level that must be considered for climate change adaptation.⁴ According to the Danish Meteorological Institute (DMI), storm surges will be much more severe in the next 50 years due to a rise in mean sea level. In addition, it is estimated that storm surges, which today statistically occur every 20 years, could occur every year by 2050.⁵

To protect low-lying land against flooding and storm surges, dikes or other permanent installations have been built along about 1800 km of the Danish coastline. In addition, Denmark has been divided into three areas: the Wadden Sea, the west coast of Jutland and the Inner Coasts (all coasts from Skagen southwards on the eastern side of Jutland and the rest of eastern Denmark). For each of these areas, three possible scenarios for the increase in storm surge water levels have been developed.⁶

About 80 percent of the Danish population lives in urban areas connected to the coast. According to the Danish Coastal Authority (DCA, *Kystdirektoratet*) approximately 430,000 people in Denmark are currently at risk of being directly affected by flooding from the sea and/or coastal erosion.⁷ According to DCA's national risk mapping, *Kystplanlægger.dk*, risk reduction is currently recommended for approximately 2,160 km of the Danish coastline. In 50 years, this is estimated to increase to approximately 3,070 km of coastline affecting approximately 523,000 people.

The following sections explore key actors and responsibilities at different governance levels, as well as key legal documents, knowledge base, digital tools, and financial mechanisms used for adapting to current and future challenges related to sea level changes in Denmark.

³ DK Miljøministeriet (2023a). Regeringen er klar med sit udspil til Klimatilpasningsplan 1

<https://mim.dk/nyheder/pressemeddelelser/2023/oktober/regeringen-er-klar-med-sit-udspil-til-klimatilpasningsplan-1>

⁴ DK Kystdirektoratet (2019). Højvandsstatistikken <https://kyst.dk/publikationer/oversvoemmelse/hojevandsstatistikker>

⁵ DMI (2022). Klimaatlas-rapport [Klimaatlas-rapport \(dmi.dk\)](https://klima.dk/klimaatlas-rapport)

⁶ DK Kystdirektoratet (n.d.). Vandstande <https://kyst.dk/klimatilpasning/kystdynamik/vandstande>

⁷ DK Miljøministeriet (2023b). Klimatilpasning: Pulje på 150 mio. kr. åbner for ansøgninger til kystbeskyttelse- <https://via.ritzau.dk/pressemeddelelse/13765566/kystpulje-150-mio-kroner-til-kystbeskyttelse-i-hele-landet>

3.1 Climate Change Adaptation in Denmark

Climate change adaptation in Denmark is a **multi-faceted endeavour** where governmental and non-governmental actors work together across several governance levels. Evidence of this can be seen for example in the national adaptation portal [Klimatilpasning.dk](https://www.klimatilpasning.dk) – “Climate change and adaptation knowledge - all in one place” (further explained in Section 3.3.1 and Figure 1 on page 17). The portal, hosted by the Danish Environmental Protection Agency (DEPA, *Miljøstyrelsen*), under the Ministry of Environment of Denmark (*Miljøministeriet*), is the result of cross-sectoral collaboration between a number of ministries, agencies, and stakeholders, as well as KL-Local Government Denmark (*Kommunernes Landsforening*, interest organization of the 98 Danish municipalities) and Danske Regioner (interest organization for the five Danish regions).⁸

The **first National Adaptation Strategy** was established by the Danish government in 2008 (Gram-Hanssen et al., 2023). The strategy recognized the need for cross-sectoral collaboration and emphasized the importance of public participation in developing and implementing adaptation measures. As a direct result of the NAS, [Klimatilpasning.dk](https://www.klimatilpasning.dk) was established. The strategy outlined specific goals, measures, and responsibilities for actors in both the public and private sectors. The Danish government provides the framework for climate change adaptation including technical support and advice to underpin the development of local adaptation plans and their implementation. In 2012, the National Adaptation Strategy was supplemented by a **National Action Plan** that made it clear that climate change adaptation is first and foremost locally based at the municipalities, authorities, companies or individuals in Denmark (Gram-Hanssen et al., 2023).

Climate change adaptation is an evolving field in Denmark. Plans and strategies are developed as new information becomes available and as challenges become more apparent. In **October 2023**, a **new national plan for climate adaptation, Climate Adaptation Plan 1** (*Klimatilpasningsplan 1*), was presented by the national government. The plan particularly targets municipalities and landowners. The plan aims, among other things, to strengthen efforts to **address the impacts of climate change on coastal areas** and find solutions for the structural problems that the municipalities have highlighted.⁹ The plan aims to speed up projects that protect Denmark against flooding from the sea. Six elements have been highlighted in the Climate Adaptation Plan 1.¹⁰ Five of these elements are relevant for governance of sea level changes:

- Involvement of the national government (*Staten*) in **coastal protection projects for six areas estimated to be at the highest risk** and with the potential of greatest damage costs. An important aspect of this initiative is that this is a **collaboration between the national government and the municipalities**. The national government will not take over the municipalities’ projects but rather support them. Help will be offered, e.g. in selecting technical solutions, preparing payment models, carrying out financial calculations or environmental assessments. The support will depend on the project phase and what the municipalities need assistance with. It is expected that the physical and processual challenges in the six projects will not be the same.¹¹ Furthermore, learnings from each collaboration should be shared with other municipalities.

⁸ <https://www.klimatilpasning.dk/omportalen/> (accessed 04.10.2023)

⁹ DK Miljøministeriet (2023a).

¹⁰ DK Miljøministeriet (2023c). Regeringens udspil til Klimatilpasningsplan 1 <https://mim.dk/kampagner/klimatilpasning>

¹¹ Interview with DCA, November 2023

- **Extension of the funding pool for coastal protection** (*Kystbeskyttelsespuljen*). Initially set for 2021-2023, municipalities could apply to this fund for joint coastal protection measures and dikes along the Wadden Sea, specifically for construction purposes. It should be noted that this funding is not applicable for maintenance or consultant support. The fund has been extended for an additional year (2024), with DKK 150 million allocated to it.
- **Allocation of a total of DKK 1.3 billion** for all initiatives under the new plan.¹² The government proposes to finance the Climate Adaptation Plan 1 from the Financial Bill (*Finanslovsforslaget*) for 2024, the Green Fund (*Grøn Fond*), and the government's reserve (*regeringsreserven*).¹³
- **Protection of Denmark's west coast**, especially vulnerable to flooding and coastal erosion (*kysttilbagerykning*).¹⁴ It is proposed that from the DKK 1.3 billion, DKK 1.1 billion will be used for this purpose, specifically for protection through beach nourishment and investment in technical facilities.
- **Establishment of a permanent committee of civil servants** (*et fast embedsmandsudvalg på afdelingschefniveau*), who have a duty to continuously advise the government on next steps in Denmark's climate adaptation and ensure that Denmark is prepared for extreme weather events.

The other highlighted elements of the presented plan refer to the **management of groundwater level** (i.e., municipalities becoming the responsible authority for handling the increasing levels of groundwaters), and the adaptation of procedures for **collective solutions for coastal areas**.¹⁵ As clarified by one of our informants, currently, wastewater companies (*spildevandsselskaberne*) have the authorization to create collective solutions for wastewater and rain (interviews, Denmark). As part of the Climate Adaptation Plan 1, the Coastal Protection Act (*kystbeskyttelsesloven*) will be revised to explore possibilities for expediting the processes for coastal protection. One of the solutions being investigated is if a setup like the one that the wastewater companies have, could be used for the coasts as well.

In Denmark, the measures for **coastal protection vary across the country**. For example, the Øresund Tunnel is protected from the impacts of climate change with dikes and a concrete wall, while large parts of the west coast are protected by beach nourishment. A high-water wall in Lemvig protects the town and creates a recreational urban space. Locks in Hvide Sande and Thorsminde drain Ringkøbing and Nissum fjords and their catchments.¹⁶

Finally, Denmark recognizes that while it is expensive to adapt to climate change, it can be costly not to do so. The Danish Ministry of Environment, in their October 2023 press release about the Climate Adaptation Plan 1, stated that screening tools show the potential costs of coastal flooding damages. Specifically, they mention that according to the Coastal Planner (*Kystplanlægger*, see Section 3.3.3), potential damage costs of 100-year events in 2020 in some coastal towns could amount to, e.g., DKK 9.5 billion for Køge Bugt, DKK 3.7 billion for Esbjerg, DKK 1.3 billion for Vejle, DKK 1 billion for Aalborg and DKK 0.8 billion for Svendborg.¹⁷

¹² Sådan vil regeringen beskytte kyster og byer mod oversvømmelser. <https://www.altinget.dk/artikel/embedsmandsudvalg-sandfodring-og-faglig-statslig-hjaelp-faa-et-overblik-over-regeringens-foerste-klimatilpasningsplan> (accessed 10.10.2023)

¹³ DK Miljøministeriet (2023c).

¹⁴ DK Miljøministeriet (2023c).

¹⁵ DK Miljøministeriet (2023a).

¹⁶ DK Miljøministeriet (2023a)

¹⁷ DK Miljøministeriet (2023a)

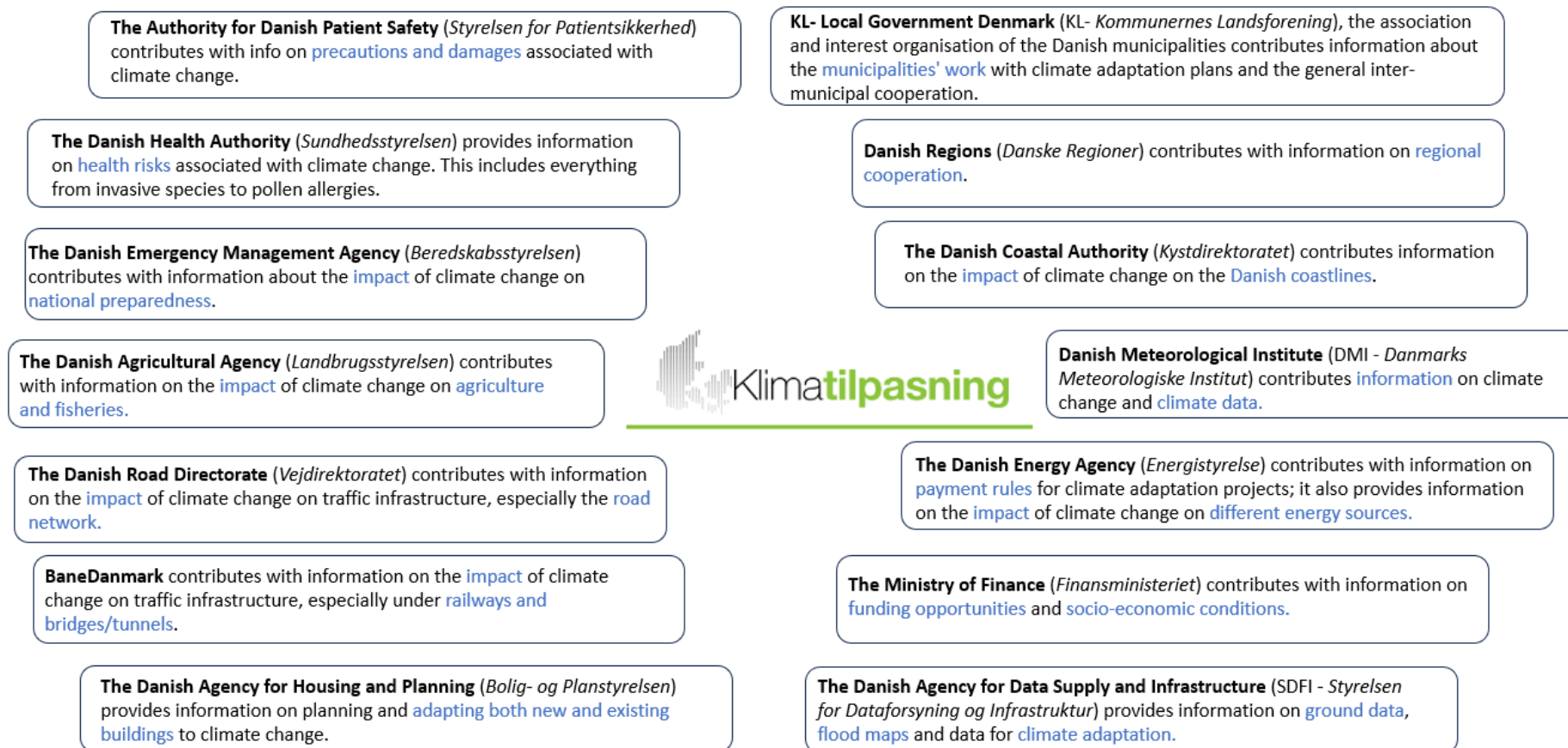


Figure 1. The cross-sectoral collaboration of klimatilpasning.dk. This portal is hosted by the **Danish Environmental Protection Agency (DEPA)** under the Danish Ministry of Environment (*Miljøministeriet*). Source: Klimatilpasning.dk (2022), <https://www.klimatilpasning.dk/omportalen/bidrag-fra-samarbejdspartnere/>

3.2 Governance Arrangements for Managing Sea Level Changes

3.2.1 Actors, roles, and responsibilities in sea level governance (at various levels)

Several actors are involved in sea level governance in Denmark, contributing to processes of decision-making, planning, and capacity building (Figure 2).

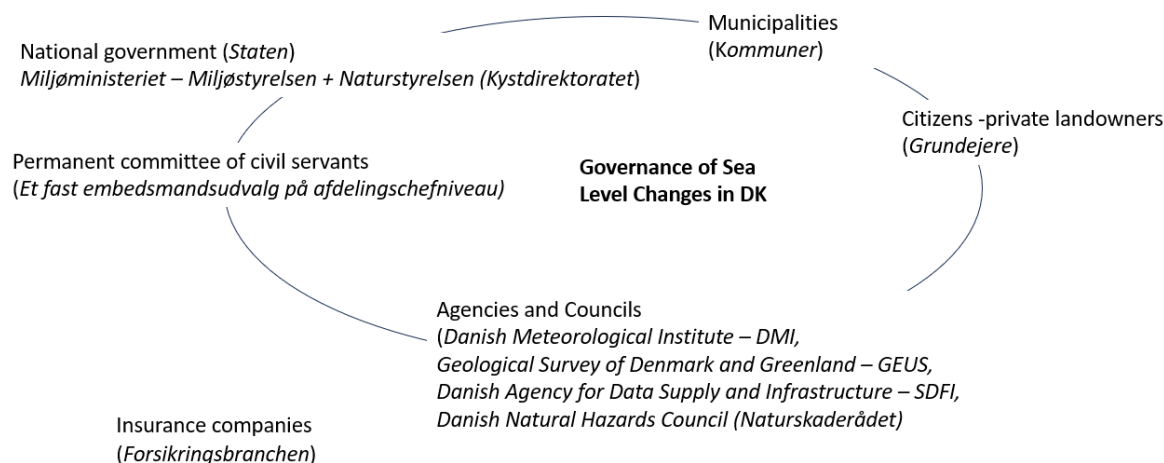


Figure 2. Key actors in the multi-level, multi-actor governance of sea level changes in Denmark.

National government (Staten)

One of the main roles of the national government is to establish an appropriate legal framework for climate change adaptation. This framework sets out the rules for governance of sea level changes in Denmark. In addition to setting regulations and strategies, the national authorities also have a key role in providing information and ensuring coordination (Gram-Hanssen et al., 2023).

Four actors from the national government are central to the governance of sea level changes. These are **the Ministry of Environment of Denmark (Miljøministeriet)**, under which operate two agencies: **the Danish Nature Agency (DNA, Naturstyrelsen)** and **the Danish Environmental Protection Agency (DEPA, Miljøstyrelsen)**. **The Danish Coastal Authority (DCA, Kystdirektoratet)** is a unit within the DNA. Out of the approximately 670 employees at the DNA, about 100 work for the DCA.

The DCA is the official coastal government agency and **the authority for the Danish coastline and 103,000 km² of Danish territorial waters**. It **manages functional and regulatory tasks** concerning coastal protection, dune conservation, beach protection and the Danish state's sovereignty over territorial waters (

Figure 3). The **DCA guides citizens, municipalities and other stakeholders** in matters concerning the coast.¹⁸ The DCA does not make laws and regulations but ensures that they are complied with.

¹⁸ <https://kyst.dk/om-kystdirektoratet/om-os> (accessed 20.10.2023)



Ministry of Environment
of Denmark
Coastal Authority

- Danish Ministry of Environment, Randbøl
The Danish Coastal Authority/Lemvig
- Administration of the coastal zone
 - Beach protection zone
 - Sand dune conservation zone
 - Certain facilities and activities on the Danish territorial waters
 - State Coastal protection
 - Bypass and recovery of clean sediment from maintenance dredging
- Responsible for coastal protection
- Joint venture on coastal protection
- Technical dike inspection
- Areas with storm surge warning service
- Areas identified in the Floods Directive
- Maintenance of the water depth in waterways and port entrances
- Maintenance of port works
- × Maintenance of sluices
- Maintenance of the Rømø dike



Figure 3. The map shows the Danish Coastal Authorities work areas. Source: DCA.

Specific tasks of the DCA that relate to the governance of sea level changes are:

- **Providing municipalities with guidance and capacity building** on the Coastal Protection Act, management of coastal protection projects,¹⁹ distribution of costs for coastal protection²⁰ and technical solutions for coastal protection.²¹ An overview of the course material used for capacity building can be found on DCA's website.²²
- As part of implementing the EU Floods Directive, the DCA **designates areas with significant coastal flood risk (oversvømmelsesrisiko)** across Denmark, using the Coastal Planner (*Kystplanlægger*, see Section 3.3.3) and a standardized methodology detailed in a report last revised in January 2023²³. The results, including **coastal flood hazard and risk maps for current and future scenarios** considering sea level rise, wind changes, wave patterns, and land uplifts, are available on the [web GIS portal](#) of the DCA.²⁴ This information is also handed over to the affected municipalities, which then must make a **flood risk management plan**. Not all municipalities are obliged to create such flood risk management plans; only those municipalities that encompass areas defined as being at high flood risk according to the assessment are required to do so.
- **Advising on joint municipal projects (fællesprojekt)**. Coastal protection is often most cost-effective and efficient if it is established over longer stretches of coast and coordinated among neighboring municipalities.²⁵ The municipalities have the leading role in these joint projects, but the DCA provides guidance and expert advice.

¹⁹ <https://kyst.dk/klimatilpasning/kystbeskyttelse/sagsbehandling/kommunale-faellesprojekter> (accessed 20.10.2023)

²⁰ <https://kyst.dk/klimatilpasning/kystbeskyttelse/sagsbehandling/bidragfordelingsmodeller> (accessed 20.10.2023)

²¹ <https://kyst.dk/klimatilpasning/kystbeskyttelse/kystbeskyttelsesmetoder> (accessed 20.10.2023)

²² <https://kyst.dk/klimatilpasning/kystbeskyttelse/undervisningsmateriale> (accessed 19.12.2023)

²³ <https://kystplanlaegger.dk/om-kystplanlaegger/om-metoden> (accessed 19.12.2023)

²⁴ <https://gis.nst.dk/portal/apps/webappviewer/index.html?id=7d399b34b9ef42d7895569d0ccc0046b>

²⁵ DK Kystdirektoratet (2022). Kommune med kystansvar Modul 2. [modul_2_kommuner-med-kystansvar-rev-2022.pdf \(mst.dk\)](#)

- Defining a list of parameters** that the municipalities should take into account when determining **plinth elevations** (*sokkelkote*). Plinth elevations refer to the specified height above ground level at which the base of a building or structure is set (**Error! Reference source not found.**). This elevation is a critical factor as it determines the lowest floor level of a building to protect it from potential flooding or water damage. When setting plinth elevations in local plans, the DCA recommends that the municipality should consider a minimum plinth elevation for new and replacement construction in the local plan area. Among the parameters are the building's lifespan and location, the expected storm surge water level and the expected damage potential in the event of a flood.²⁶

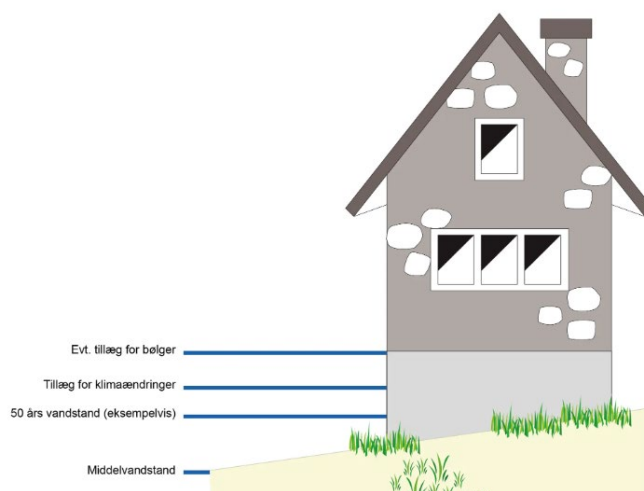


Figure 4. Examples of plinth elevations to consider as part of the local planning. Legend from top to bottom reads: Possible supplement for waves; Climate change supplement; 50-year water level (example); and Average sea level. Source: DCA.

- Protecting against storm surges.** Storm surge preparedness (*stormflodsberedskaber*) has been established for two areas along the west coast of Jutland - the central part of the West Coast and the Wadden Sea area in South Jutland. The emergency response is divided into two independent units as the warning criteria and response options for the two areas are different. The measures have been established in collaboration between the DCA, the police and the former counties (*de tidligere amter*). Measures have been set to be able to warn and possibly evacuate the population in threatening situations.²⁷ The DCA's team (*beredskabsteam*) consists of three people from September to April and one person for the rest of the year.²⁸

A permanent committee of civil servants (et fast embedsmandsudvalg på afdelingschefniveau)

As part of the new Climate Adaptation Plan 1, the establishment of a civil servant committee is planned. The role of the committee will be to continuously advise the national government on next steps for Denmark's climate adaptation to ensure that Denmark is prepared for extreme weather events.²⁹ The committee will be formed by high level civil servants from across different ministries.

Municipalities (*Kommuner*)

During the period 2013-2015, municipalities had to develop mandatory climate adaptation plans. Following the NAP's publication in 2012, the government at the time and the municipalities agreed that all municipalities would carry out a risk assessment and prepare municipal climate change adaptation plans, supported by a task force established by the Ministry of Environment. All 98 Danish municipalities finished their plans in 2014. However, there were no formal requirements for future revisions (Gram-

²⁶ Kystdirektoratet (n.d.) Planlægning. Kystdirektoratets anbefalinger til lokalplaner.

<https://kyst.dk/klimatilpasning/kystbeskyttelse/sagsbehandling/planlaegning>

²⁷ Kystdirektoratet (n.d.) Kystdirektoratets stormflodsberedskaber <https://kyst.dk/klimatilpasning/stormflod-og-beredskab/kystdirektoratets-stormflodsberedskaber>

²⁸ Kystdirektoratet (n.d.) Stormflodsberedskabet i Syd- og Sønderjylland <https://kyst.dk/klimatilpasning/stormflod-og-beredskab/kystdirektoratets-stormflodsberedskaber/beredskab-i-syd-og-soenderjylland>

²⁹ DK Miljøministeriet (2023a).

Hanssen et al., 2023). Currently under the DK2020, which is voluntary, 96 out of 98 municipalities are developing climate changes adaptation plans.

Furthermore, with the revised **Planning Act of 2018** municipalities became **legally obliged to consider flooding and coastal erosion in their physical planning**. As per the Planning Act it is compulsory to introduce mitigation or remedial measures if planned areas are found to be exposed to coastal flooding or erosion (Gram-Hanssen et al., 2023).

In June 2017, the national government and KL-Local Government Denmark (*Kommunernes Landsforening*) entered into an agreement that **the municipalities would take over the role as the authority responsible for coastal protection projects** from the DCA. The agreement came into force **1st of September 2018**.

In August 2017, the national government launched further initiatives for the coastal area. Among other things, it was decided that a nationwide **assessment of the risk of flooding and erosion** would be carried out and that **guidance on solutions for risk management** would be prepared by the DCA. It was also decided that a guide for the municipalities on the **distribution of the cost of municipal joint projects** and a **guide on coastal protection methods** should be prepared. The DCA developed a document which guides municipalities through the cost allocation process, including cases for inspiration, as well as provided training courses. As previously described, the DCA still organises courses in the coastal protection act, legislation processes, coastal engineering etc. to support the municipalities.

The transfer of the regulatory task was part of a series of government initiatives aimed at **making it easier for citizens to protect their coastal properties**. Whereas citizens previously had to apply for permits from several authorities to carry out a coastal protection project, as of September 2018, citizens only need to apply for a permit from the municipality.³⁰

Almost all Danish municipalities have voluntarily signed to become both climate neutral and climate resilient by 2050. Launched in 2019, the **DK2020 program** aims to accelerate the implementation of the Paris Agreement goals in Denmark. Currently 96 of the 98 Danish municipalities have voluntarily chosen to join this initiative.³¹ As part of the DK2020 work, the municipalities have committed to prepare new flood risk assessments and select specific areas for which action plans are to be prepared.³²

Specific tasks for the municipalities that relate to the governance of sea level change are:

- Following the **Planning Act of 2018**, municipalities are **obliged to consider flooding and coastal erosion in their municipal spatial planning**. It is compulsory to introduce mitigation or remedial measures if planned areas are found to be exposed to coastal flooding or erosion (Gram-Hanssen et al., 2023). The intention is that through the municipal plan, municipalities can require mitigation measures in areas designated as potential coastal flood or erosion risk areas.
- Formulating **risk management plans (as defined by DCA related to the implementation of the EU FD)**. This task applies only to those municipalities, which extend over an area/areas, that has been appointed as a risk area by the DCA.
- Preparing **climate adaptation plans**. This task is voluntary for the municipalities not identified by the DCA as risk areas and is part of the DK2020 plan. These voluntary climate adaptation plans are updated every four to five years.

³⁰ Kystdirektoratet (2018). [Hjælp til selvhjælp: Kystdirektoratet er klar med nye vejledninger til kommunernes kystbeskyttelse - Kystdirektoratet](#)

³¹ CONCITO (n.d.) DK2020 <https://concito.dk/projekter/dk2020-klimaplaner-hele-danmark>

³² Klimatilpasning (n.d.) DK2020 -[DK2020 \(klimatilpasning.dk\)](#)

- Taking the lead in **joint municipal projects** (*fællesprojekt*). As previously mentioned, coastal protection is often most cost-effective and efficient if it is established over longer stretches of coast (see Figure 5). Municipalities are the driving force in joint municipal projects.

The municipalities play a major role in the roll-out of the initiatives of the Climate Adaptation Plan 1. The Local Government Denmark (KL) view the initiatives under the plan positively, “The plan contains several of the initiatives that we in the municipalities have requested, and now we need to implement them.” (Birgit S. Hansen, Chair of the Climate and Environment Committee, KL).³³

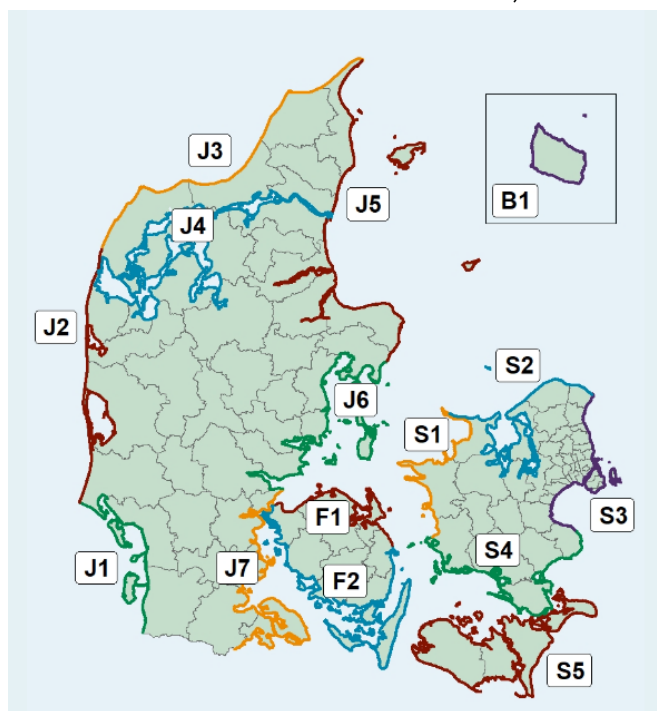


Figure 5. Denmark has categorised the entire Danish coastline into 15 main stretches, based on overall geographical conditions and prominent fixtures in the landscape, such as fjords, headlands and bridges. This means that a main stretch will often cross municipal boundaries. On the Coastal Planner, managed by DCA, different maps for these coastal areas are available including risk assessments of coastal flooding and erosion (see more in Section 3.3.3). Source: Kystplanlægger.dk

Citizens – landowners (grundejere)

Climate adaptation in Danish coastal areas is a task shared by municipalities and citizens in their role as private property/land owners (Hofmann et al., 2015). One of the aims of the amendment to the Coastal Protection Act (*Kystbeskyttelsesloven*) in September 2018 was to support citizens in being well prepared for future climate change.³⁴

Specific tasks for citizens that relate to the governance of sea level changes are:

- Taking responsibility to **protect their coastal properties**. The Coastal Protection Act currently states that those who benefit from coastal protection can be obliged to finance it (i.e., the landowners pay). This is seen as having both positive and negative effects. The positive effect is that affected citizens will have ownership of the projects, avoiding an apathic view that the government will “come and fix

³³ DK Miljøministeriet (2023a).

³⁴ Kystdirektoratet (2022). Kommune med kystansvar Modul 2. modul_2_kommuner-med-kystansvar-rev-2022.pdf (mst.dk)

the problem”.³⁵ The negative effects relate to inequalities with payments.³⁶ The division of costs for coastal protection is to be addressed in the upcoming revision of Coastal Protection Act under the new Climate Adaptation Plan 1, on how the costs are divided (*bidragsfordeling*).

- Awareness of the **obligations** linked with the ownership of coastal properties. **Guidelines for building in coastal areas**³⁷ aimed at developers in connection with new construction, renovations and extensions in coastal areas was prepared in 2018 by the Danish Agency for Housing and Planning (*Bolig- og Planstyrelsen*)³⁸. The guidance has since then been regularly updated by the Danish Building Research Institute (SBI) on behalf of the authorities. The guidance provides information on how to reduce the risk of damage to buildings in coastal areas, **primarily related to storm surges and sea level rise**. Awareness also relates to the **changes of property boundaries** ([cadastral map](#)) and to [permit requirements](#) for coastal protection measures.
- Under the concept of innovative climate adaptation (*innovativ klimatilpasning*), citizens have a more active role within climate adaptation (Hoffmann et al., 2015). For example, citizens can request the municipality to initiate a joint municipal project ([fællesprojekt](#)).

Other actors

Two other sets of actors are included in the overview of actors in Figure 2. The role of the different **agencies** (e.g., DMI, GEUS, and SDFI) is being discussed in other sections of this chapter.

Insurance companies (*forsikringsbranchen*) are handling insurance cases after the occurrence of extreme weather events. The money used for these compensation cases comes from **the Danish Natural Hazard Council** (*Naturskaderådet*), that decides which events qualify for compensation following certain criteria (see Section 3.4.2). Insurance companies could furthermore play a role as potential providers of knowledge: “[...] We have helped many homeowners with water damage, so we have a good insight into where damage typically occurs after extreme weather events [...] we are ready to share suggestions for action, but this requires that we are given the opportunity to share our data and knowledge”.³⁹ The data that insurance companies hold, could add important information to the knowledge base for the governance of sea level changes (interviews, Denmark). However, there are challenges regarding access to these data as they are protected under general data protection rules.

3.2.2 Key policies, programs, and planning guidelines for sea level governance

A number of national laws and regulations are important for climate change adaptation and the governance of sea level changes in Denmark: (Figure 6):

- **The Coastal Protection Act** (*Kystbeskyttelsesloven*, [LBK nr 705 af 29/05/2020](#), *Miljøministeriet*). The purpose of coastal protection is to **protect people and property** by reducing the risk of flooding or coastal erosion from the sea, fjords or other parts of the territorial sea. Capacity building material on aspects related to the administration of this Act has been prepared by the DCA for coastal municipalities.⁴⁰
- **The Planning Act** (*Bekendtgørelse af lov om planlægning; Planloven*, [LBK nr 1157 af 01/07/2020](#)). Municipalities can protect coastal areas against flooding and erosion through **preventive spatial planning**. The intention is that the municipality, through the municipal plan, can require mitigation measures in areas designated as potential flood or erosion threats.

³⁵ Interview with informant, November 2023

³⁶ [Trods borgerstorm melder kommunen pas: Oversvømmede husejere står selv med regningen for klimasikring | Klima | DR](#)

³⁷ Vejledning om byggeri i kystnære områder - til bygherrer vedrørende sikring mod stormflod og vandstigninger https://byggningsreglementet.dk/Vejledninger/Klimasikring/Vejledning_Klimasikring/Byggeri_i_kystnaere_omraader

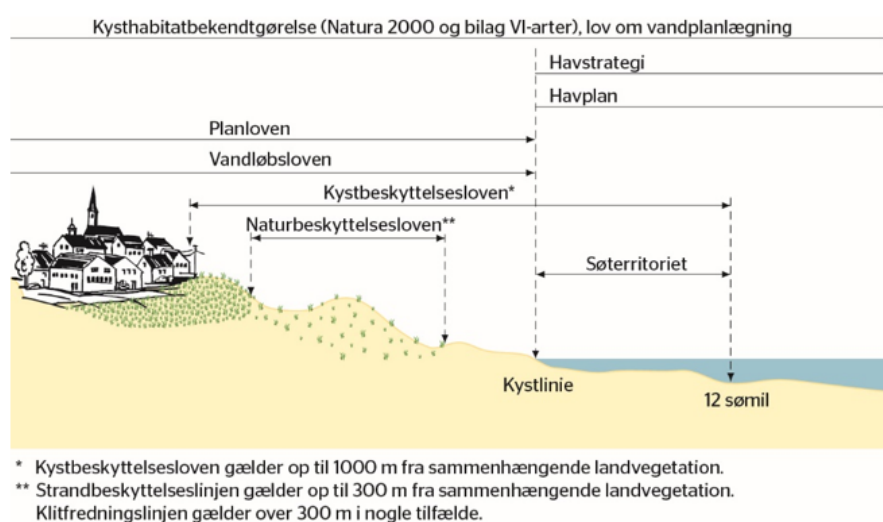
³⁸ This agency was terminated 15.12.22. Tasks were transferred to other units. Building regulations are handled by the Danish Authority of Social Services and Housing

³⁹ DK Miljøministeriet (2023a). Publicly available statement from actor in the insurance industry.

⁴⁰ <https://kyst.dk/klimatilpasning/kystbeskyttelse> (accessed 04.11.2023)

- **The Floods Acts** (*Oversvømmelsesloven*) contains provisions implementing the EU Floods Directive 2007/60/EC (EU FD). It aims to reduce the negative consequences that extreme floods (including flooding from the sea) can have on human health, the environment, cultural heritage and economic activity.⁴¹ The EU FD is implemented into Danish national legislation through two instruments. The first is [LBK nr. 1085 af 22/09/2017 Bekendtgørelse af lov om vurdering og styring af oversvømmelsesrisikoen fra vandløb og søer](#)⁴²; the second instrument is [BEK nr. 894 af 21/06/2016 Bekendtgørelse om vurdering og risikostyring for oversvømmelser fra havet, fjorde eller andre dele af søterritoriet](#).⁴³ The purpose of the instruments is to set guidelines for flood risks and the **responsibilities given to the state and municipalities**. DCA is the responsible national authority for the implementations of the EU FD in Denmark.

Øversigt over lovgivning i kystzonen ift. kystbeskyttelsesprojekter



5 / Kystdirektoratet / Kystbeskyttelsesloven

Figure 6: Overview of coastal zone legislation for coastal protection projects. Source: DCA⁴⁴.

3.3 Knowledge Base and Tools for Sea Level Changes

3.3.1 Klimatilpasning.dk – National climate adaption portal

As mentioned earlier, **the climate adaptation web portal [klimatilpasning.dk](#)** is anchored in the Danish Environmental Protection Agency (DEPA). The information can be found either by **target group** (citizens, municipalities, business) or by **topic** (e.g. information on the latest research and development in climate adaptation in Denmark and abroad; information on a variety of support schemas- i.e. private, public, or originating from the EU; sources of funding for specific climate adaptation projects; and upcoming events and news). Several of the tools offered on the portal are of relevance for the governance of sea level changes. Figure 7 gives an overview of these tools, a selection of which is introduced in the following sections.

⁴¹ <https://oversvommelse.kyst.dk> (accessed 04.11.2023)

⁴² Executive Order of the Act on the Assessment and Management of Flood Risks from Watercourses and Lakes

⁴³ Executive Order on the assessment and risk management of flooding from the sea, fjords or other parts of the territorial sea

⁴⁴ <https://kyst.dk/klimatilpasning/kystbeskyttelse/undervisningsmateriale> (accessed 04.11.2023)

3.3.2 Climate change projections – Klimatlas (the Climate Atlas)

The Danish Meteorological Institute (DMI) develops climate projections for Denmark based on the global IPCC data and provides information on how the climate change affects Denmark under different scenarios. DMI makes the information available via the **Climate Atlas (Klimatlas)**.⁴⁵

The scenarios available in the Climate Atlas is the RCP scenarios (Representative Concentration Pathways) based on the IPCC AR5 report and the more recent SSP (Shared Socioeconomic Pathways) scenarios based on the AR6 report. In the atlas a combination of these two sets of scenarios is used, **where atmospheric indicators are based on RCPs, while ocean indicators are based on SSPs**. Currently there are three scenarios available in the map-based version of the atlas up until the year 2100: **a low (RCP2.6/SSP1-2.6), a medium (RCP4.5/SSP3-4.5) and a high (RCP8.5/SSP5-8.5)** emission scenario. However, it is **possible to download calculations for all scenarios used by the IPCC**, including low- and medium-confidence calculations.⁴⁶ For each municipality, a report and data file can be downloaded that describes the expected sea level changes associated with the different scenarios, and the 50 percent (median), as well as 10 and 90 percent percentiles values. On the platform it is possible to **download data of sea level projections up until year 2150** (even though this time horizon is currently not shown in the maps).

As the IPCC AR6 also includes estimates of risks beyond the most likely and for the **95th percentile values for sea level rise**, DMI informs on their website that they are working on a description of this in relation to sea level around Denmark, which will be included in a future update. For planning that require particular robustness, DMI recommends worst-case analyses. Here, DMI recommends that the assessment of high storm surge events in today's climate, including uncertainty assessment, and the 95th percentile for the rise in mean sea level in a high discharge scenario is included in the worst-case analysis.⁴⁷

Guidance on which climate scenario is relevant to use for different projects is provided in a document from 2018 prepared by DMI in collaboration with DEPA.⁴⁸ The guidance says that both the timeframe for when a project will be executed/implemented and the life span of the infrastructure should be considered. Sea level allowances must be included into the planning process, in particular when constructing something with a long lifespan to accommodate the possibility of future increases in sea levels⁴⁹. Following the update of the IPCC AR6 projections, **the national authorities are working on a new set of guidance** for 2024. The DCA is collaborating with DEPA and DMI to update the guidance.

Related to coastal planning and protection, the DCA recommends that medium to high robustness requirements are set. Currently, the RCP8.5 scenario is used in the Coastal Planner (*Kystplanlægger.dk*) for risk assessments (see Section 3.3.3). The Coastal Planner is nationwide, so the resilience requirements vary. However, since it can be used for planning urban development and coastal protection in municipalities, this scenario was chosen. Yet, as mentioned the authorities are working on updating the assessments. It is indicated that Denmark will be using the **SSP3-7.0 scenario**, but this is not decided yet. Furthermore, informant shared that for **coastal protection for Copenhagen, SSP3-7.0 is used** and that for the rest of the country, scenarios **SSP5-8.5 and SSP2-4.5 are used for coastal planning**⁵⁰.

⁴⁵ <https://www.dmi.dk/klima-atlas/data-i-klimaatlas> (accessed 04.01.2024)

⁴⁶ <https://www.dmi.dk/klima-atlas/data-og-rapporter-klimaatlas> (accessed 11.01.2024)

⁴⁷ [Teknisk beskrivelse af data i Klimaatlas \(dmi.dk\)](#) (accessed 11.01.2024)

⁴⁸ <https://edit.mst.dk/media/4rwc5dzh/vejledningomkystbeskyttelsesmetoder18-11.pdf>

⁴⁹ <https://www.dmi.dk/klima-atlas/tekniskbeskrivelseafdataiklimaatlas> (accessed 19.01.2024)

⁵⁰ Information from informants

KlimaAtlas: A common data basis that **municipalities** can use to **plan climate adaptation**. Contains data on temperature, precipitation, water levels and storm surges in the expected future Danish climate. Data is available for all of Denmark, municipalities, water catchments and **coastal areas**. Data can be downloaded in various file formats, PDF reports and via a GIS-service.



Beregningsværk: a tool that can help calculate the **socio-economic benefits of climate adaptation**. The tool is especially targeted at **utility companies** and **municipalities** that develop **joint solutions**. The tool has been developed with the goal of **promoting dialog and joint knowledge** development.



SkadesØkonomi: The model, developed to support **municipalities'** work with DK2020 and climate adaptation, can be used to **calculate the costs of flooding**. With this tool, municipalities have the opportunity to make iterations in the process of mapping risks and prioritizing efforts. The program is continuously developed

Kommunekort (under construction) : will show the different **municipalities' climate adaptation plans** as well as the municipalities' wastewater plans and draft risk management plans and other relevant links to the work with climate adaptation in the individual municipalities.

Kystplanlægger 2120: A nationwide **mapping of the risk in coastal areas** up to 2120 prepared by the Danish Coastal Authority (*Kystdirektoratet*). Developed to help **coastal municipalities plan for the future in coastal areas**. It is supplemented with guiding strategies and proposals for concrete measures to manage flood and erosion risk.



 Klimatilpasning

KAMP: shows the areas where there are **possible climate impacts that may need further investigation** (e.g., how many buildings and how many kilometers of road could potentially be **affected by flooding**, and the estimated building value at risk). The screening tool, which compiles selected national data, calculations and projections, is particularly aimed at environmental and planning staff in **municipalities**

Klimameter: provides an overview on the different the **methods available for mapping flood risk** from extreme rainfall and **sea** in the **municipalities**. It is designed as a speedometer, where the speed corresponds to the complexity of the analysis.

Datakataloget: The catalog, compiled in December 2017, provides an **overview of the existing terrain, climate and water datasets** that are known for use in **municipalities'** climate adaptation tasks.

Figure 7: Digital tools offered to Danish municipalities, citizens, and industry as part of Klimatilpasning.dk and which several are of relevance for the governance of the sea level changes. Adapted from Klimatilpasning.dk (<https://www.klimatilpasning.dk/vaerktoejer/>).

3.3.3 Mapping of risks - Kystplanlægger.dk (the Coastal Planner)

The Danish Coastal Authority (DCA) is responsible for several key knowledge tools related to preparing for the future and adapting to climate change. The DCA applies a **risk-based approach** to coastal challenges and climate change.⁵¹ The concept of risk in the context of coastal flooding and erosion is defined as a combination of two factors: hazard and vulnerability.⁵²

The DCA has prepared **nationwide risk maps for coastal areas** up to the year 2120 in the online tool **Kystplanlægger.dk (the coastal planner)**⁵³. The tool is intended to help coastal municipalities plan for the future under a changing climate. Citizens can also use it to learn more about the coast in their areas. The maps are supplemented by **guiding strategies and proposals for specific measures** to manage the risk of coastal flooding and erosion.

Overall, the DCA has performed the following **national risk assessments for current and future climate-induced, coastal flood and erosion risk**:

- Kystplanlægger, 2020 <https://kystplanlaegger.dk/>
- Kystanaysen, 2016. <https://kyst.dk/publikationer/klimaaendringer/kystanalyse>
- Floods Directive in 2011 with a revision in the second planning cycle in 2016 (only coastal flooding) <https://oversvømmelse.kyst.dk/planperioder/planperiode-2010-2015/plantrin-1>

The 2020 nationwide risk assessment, **Kystplanlægger.dk** was completed for the about 8000 km of Danish coastline. Three time-perspectives were assessed: present (2020), as well as a 50-year and 100-year perspective **up to 2120**, using the RCP 8.5 scenario.⁵⁴ Work is currently ongoing to update the analysis based on the latest global projections (see Section 3.3.2).

Models and calculations are made looking (at least) 100 years into the future. The importance of looking also beyond 2100 is noted in the “Guide to holistic flood risk management” (*Vejviser til helhedsorienteret risikostyring af oversvømmelse*).⁵⁵ The report explains that many of the vulnerabilities, such as houses and infrastructure, have a lifespan that extends far into the future, often beyond 2100, especially in cities. The latest scenarios from the IPCC show that sea level rise will continue to accelerate after 2100 (Oppenheimer et al., 2019).

The portal is a further development of **Kystanalysen**⁵⁶ from 2016, which was intended to provide a comprehensive national picture of where coastal erosion and flooding occur and where coastal protection may be needed. According to the DCA, **Kystplanlægger.dk** provides a more nuanced risk picture that makes it possible to **summarise and compare the risk on local coastal stretches across the country** on a consistent basis, and it brings together the latest knowledge on coastal flood and erosion risk.⁵⁷

⁵¹ DK Kystirektoratet (n.d.) Risiko og sårbarhed [Risiko og sårbarhed - Kystdirektoratet](#)

⁵² ByplanNyt (2020) Guide til dynamisk planlægning af klimatilpasning og styring af risikoen for oversvømmelse i kommuner [ByplanNyt_20210317.pdf \(byplanlab.dk\)](#)

⁵³ <https://kystplanlaegger.dk/> (accessed 10.01.2024)

⁵⁴ Climate ADAPT (2023)

⁵⁵ DK Kystdirektoratet (2022). *Vejviser til helhedsorienteret risikostyring af oversvømmelse C5a - Vejviser til helhedsorienteret risikostyring af oversvømmelse - Kystdirektoratet*

⁵⁶ <https://kyst.dk/publikationer/klimaaendringer/kystanalyse> (accessed 10.01.2024)

⁵⁷ Kystdirektoratet (2023) <https://kyst.dk/media/128517/pulje-ofte-stillede-spoergsmaal-juni-2023.pdf>

Three types of maps for an area are included in the Coastal Planner and associated webGIS portal (see Figure 8 on page 17):

- **Hazard maps** (*oversvømmelses- og erosjonsfare*) show where respectively coastal flooding and erosion will occur under different storm surge scenarios. The maps differ depending on the severity of the storm surge and when it occurs: In a present-day perspective (2020), in 2070 and in 2120. For each time perspective, the flooding extent is shown, i.e. what area would potentially be flooded in a 50-, 100-, 1000- and 10,000-year event. In addition, the maps provide information about the water depth of the flooded areas.
- **Damage maps** (*oversvømmelses- og erosjonskade*) show the damage to the economic values in DKK in the flooded area from a specific storm surge event, e.g. a 100-year event in 2120.
- **Risk maps** (*oversvømmelses- og erosjonsrisiko*) also show economic damage for an area, but for these maps the average of the damage from the different storm surges that have been calculated is shown, weighted according to the probability of the storm surges. The risk is calculated in DKK per year. The risk mapping for the coasts has three time-perspectives: 20 years, 50 years and 100 years.

Based on the risk calculation, the Coastal Planner **recommends spatially explicit strategies for when the risk on a stretch of coastline is acceptable and when it should be reduced**. Such strategy recommendations have been made for the entire Danish coastline and the strategies have, like the risk mapping, three time-perspectives: 20 years, 50 years and 100 years. For the stretches where the recommendation is that risk should be reduced, the Coastal Planner **provides technical guidance for risk reduction**. These indicative solutions are primarily about coastal protection measures, though it is noted that they should always be integrated with measures for prevention and strengthening the preparedness of the local community. Furthermore, if a municipality wishes to use the guiding solutions as a starting point, the municipality must carry out specific and more detailed studies and socio-economic analyses.

Information and data on coastal flood risk is open access and available in two web-GIS portals. The first portal is specific for [coastal flooding and erosion](#). The second portal is related to the implementation of the [EU Floods Directive](#) (second cycle). By providing this information the national authorities make sure that all municipalities have access to the same background risk information derived by the same methodology. An overview of the different webGISes is available: <https://oversvømmelse.kyst.dk/webgis> Some municipalities, e.g., Copenhagen, have in addition to the national flood hazard and risk maps developed their own maps, which might deviate from the national maps. Copenhagen has in this case decided to use the maps showing the higher risk and flooding extend⁵⁸.

On the Coastal Planner, also booklets (pdf-documents) are available for each of the 15 defined coastal areas (shown in Figure 5), where information is included about the largest local storm surge events and under which conditions different areas are potentially particularly exposed to these events. Since the descriptions are based on natural landscape boundaries and coastal dynamics rather than municipal boundaries, coastal stretches within the same municipality may be included in several booklets.

⁵⁸ Information from informant, November 2023

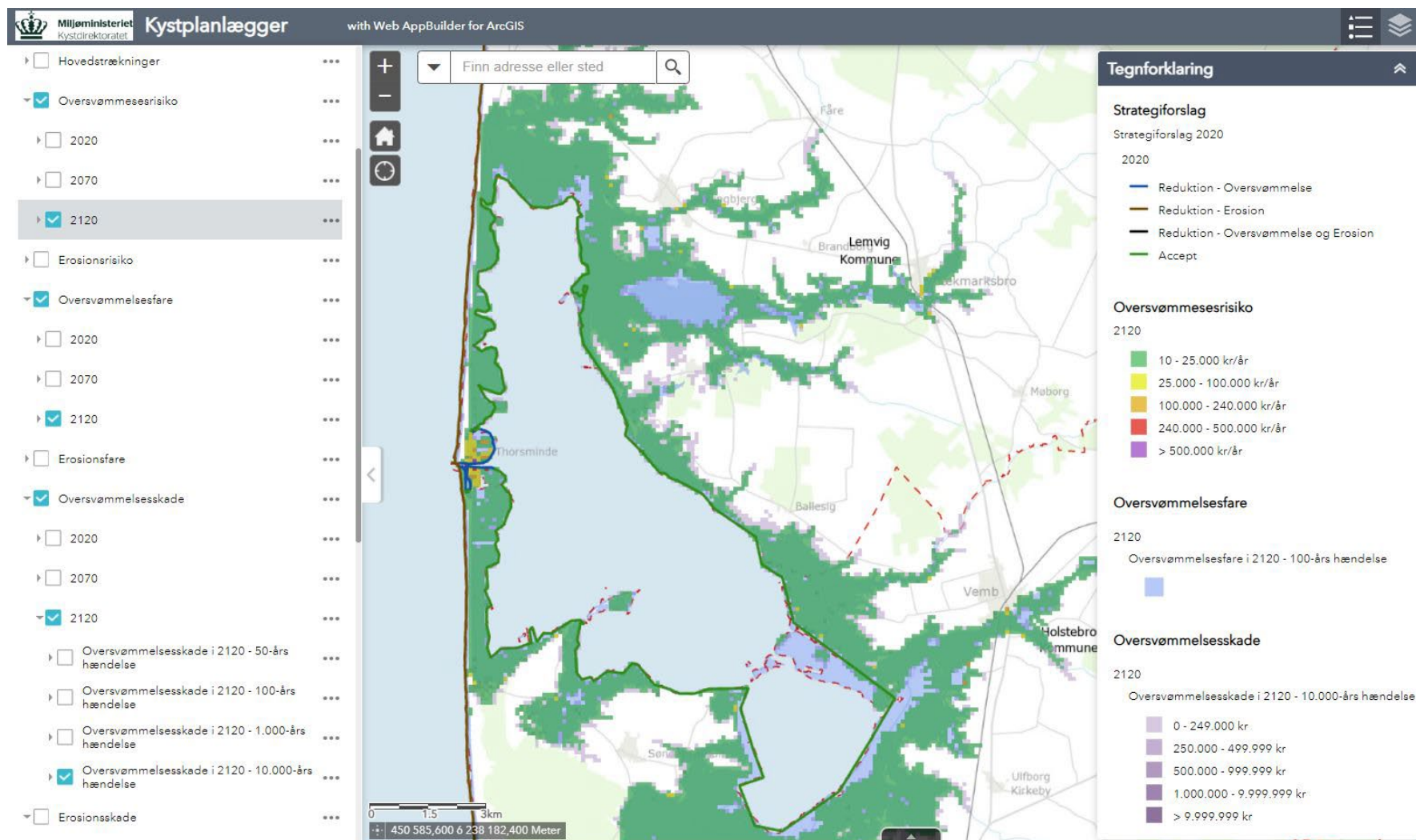


Figure 8. Example from the webGIS portal related to the Coastal Planner (Kystplanlægger.dk).

Source: <https://gis.nst.dk/portal/apps/webappviewer/index.html?id=7d399b34b9ef42d7895569d0ccc0046b>.

3.3.4 Screening tool for spatial planning - KAMP

The **screening tool KAMP** (*et klimatilpasning- og arealanvendelsesværktøj til miljø- og planmedarbejdere*) compiles selected national data, calculations and projections intended for **climate change adaptation and spatial planning purposes in municipalities**.

KAMP was developed by DEPA and the Danish Environmental portal to support municipal planning. The map-based platform contains different data layers, including general land use and administrative data and impacts of different environmental events. A selection of maps show which buildings and roads could potentially be flooded by different sources of water. KAMP is based on the most recent surveys and datasets available at national level.⁵⁹ The goal is that planning staff in the municipalities would have easy access to selected environmental, planning and property data from various national databases. **Sea levels in the future** based on climate projections from DMI and the Climate Atlas see (3.3.2) is included among the different data layers. It says on the website that the data included in the tool is produced by several different actors and not necessarily for the purpose of climate adaptation planning. It is also important to note that KAMP does not contain detailed local data and models, e.g. how planned local climate change adaptation projects will reduce the risk of flooding. The purpose is to provide the user with an opportunity to **do a screening relevant for potential further investigations**.

The KAMP platform is continuously updated. Previously developed tools available on klimatilpasning.dk, like the flood map (*Oversvømmelseskortet*) and the sea level rise map (*Havvand på land*) has been integrated into the KAMP platform. KAMP has recently been **groundwater prepped**, which means that the tool has been expanded with new data and maps showing areas with a high-water table. This feature has been called for by municipalities and other actors working with climate change adaptation. The new high-water table data and maps are being developed by the Geological Survey of Denmark and Greenland (GEUS) in collaboration with the Danish Agency for Data Supply and Efficiency, among others. According to the KAMP website the next update of the platform will be in February 2024.

3.3.5 Education material and courses for coastal municipalities

Each year, the DCA organises **several seminars and courses** where coastal municipalities can get inspiration and guidance from the authority's experts in coastal protection. Examples of topics are: Coastal dynamics and challenges; Coastal protection methods and how they work, including nature-based coastal protection; Technical information and processes concerning application for the coastal protection pool. The **educational material** throughout the years is available on a dedicated area on their website.⁶⁰

3.4 Financial Schemes and Tools Related to Sea Level Changes

3.4.1 Financing adaptation to sea level changes and coastal protection

The national authorities, the municipality, or private landowners can provide the funding for adaptation projects as it will be explained next. As previously mentioned, according to the national government's recent proposal, around DKK 1.3 billion will be spent in the coming years to secure coasts, towns, homes and infrastructure from the impacts of severe weather events.⁶¹ Although the eastern coast of Denmark

⁵⁹ <https://kamp.klimatilpasning.dk/> (accessed 04.01.2024)

⁶⁰ <https://kyst.dk/klimatilpasning/kystbeskyttelse/undervisningsmateriale> (accessed 04.01.2024)

⁶¹ Vidkjær Stone, S. (2023). Sådan vil regeringen beskytte kyster og byer mod oversvømmelser. [Sådan vil regeringen beskytte kyster og byer mod oversvømmelser - Altinget - Alt om politik: altinget.dk](#)

was worst affected by the recent storm Babet in October 2023, most of the proposed budget, DKK 1.1 billion, will be spent on the west coast, which is assessed to be most vulnerable.⁶²

The Danish Coastal Protection law permits municipalities to **request payment from landowners for coastal storm surge adaptation**. This applies both to people directly and indirectly benefitting from the adaptation activities. These payments are generally based on agreements between municipalities and landowners and are fundamentally voluntary. The payments could take form of a municipality loan, where the municipality pay up front and the landowners pay off their contribution to the municipality over e.g. a 30-year period. Commonly landowners in Denmark are organized in landowner organizations (*Grundejerforeninger*) and such agreements are often made with these organizations, and as such dependent on all agreeing. Hence, it was mentioned by one of the informants that it might be a fragile model for financing. Furthermore, there have been some opinions raised in the public sphere stating that “this approach might work well when summer cottages by the sea are affected but doesn’t make sense when it comes to large urban areas, cultural sites, or the capital Copenhagen itself, where adaptation indirectly benefits the whole population.”⁶³

Coastal municipalities in Denmark can currently apply for financial support for projects from a **temporary national coastal protection pool**⁶⁴ that is managed by the DCA. The pool supports adaptation projects addressing current and near-future risks and is aimed at making the Danish coast more resilient to withstand more extreme weather. Long-term holistic solutions that prevent coastal flooding and erosion are among the projects that may be eligible to receive co-financing from the pool. The financial arrangement came about in 2021 (see more below). In 2023, DKK 150 million was set aside for **state co-financing of coastal protection in municipal joint projects** (starting in 2024).⁶⁵ It has just been extended one more year, so it now exists in 2024 as well with DKK 150 million.

Such joint municipal projects (*fællesprojekt*) must be located within stretches where challenges have been identified through the Coastal Planner (*Kystplanlægger.dk*, see Section 3.3.3). The DCA explains that national data are used as a basis for the allocation of funds from a national pool so that all municipalities have the same starting point regardless of what local data they themselves have.⁶⁶

The DCA states that the advantage of joint municipal projects is that it is the municipality that receives the notification to use the funds and therefore **must ensure the progress of the project**. The municipalities are authorized to implement coastal protection projects and can make decisions on the **distribution of contributions for residual financing** if grants are obtained. Furthermore, such joint projects aim at ensuring that the funds are **used for larger and coherent projects that protect larger areas**. The pool is intended to support the municipalities in working holistically and incorporating coastal protection into municipal planning and climate adaptation. It is recommended to reduce erosion and/or flood risk in the short or medium term.

For the DCA to be sure that a municipal joint-project is underway, there must be a **political decision** that the municipality intends to initiate a municipal joint-project on a specific coastal stretch. Proof of this

⁶² The Local (2023). Danish government wants to buttress coasts with large amount of sand <https://www.thelocal.dk/20231023/danish-government-wants-to-buttress-west-coast-with-large-amount-of-sand>

⁶³ Clean Energy Wire (2023). Denmark keeps on dithering over climate adaptation plans <https://www.cleanenergywire.org/news/denmark-keeps-dithering-over-climate-adaptation-plans>

⁶⁴ DK Kystdirektoratet (2023). Pulje til kystbeskyttelse 2023 <https://kyst.dk/klimatilpasning/pulje-2023>

⁶⁵ Regeringen og Socialistisk Folkeparti, Liberal Alliance, Radikale Venstre og Dansk Folkeparti har med Aftale om Finansloven 2023 afsat 150 mio. kroner til den statslige pulje til kystbeskyttelsesprojekter.

⁶⁶ DK Kystdirektoratet (2023) <https://kyst.dk/media/128517/pulje-ofte-stillede-spoergsmaal-juni-2023.pdf>

decision must be attached as an appendix to the application.⁶⁷ Secondly, **documentation of self-financing**, at a minimum of 20 percent, must be attached to the application.

With the Finance Act for 2021,⁶⁸ the government at the time⁶⁹, agreed to allocate a total of DKK 350 million to increase and extend the state pool for coastal protection projects and at the same time expand the criteria for relevant applicants. DKK 50 million were allocated in 2021, in addition to DKK 40 million from the original Finance Act agreement, and DKK 150 million in were allocated 2022 and 2023, respectively.

With the **Climate Adaptation Plan 1** on the way and an ambition to speed up climate adaptation, the national government has extended the coastal protection pool by DKK 150 million in 2024, so that municipalities can continue to apply for joint coastal protection projects throughout the country as well as for the establishment or reinforcement of dikes in the Wadden Sea.⁷⁰

3.4.2 Financing storm surge losses

Storm surges in Denmark vary greatly in strength and typically hit the coasts in the months of October to April. In Denmark, residents cannot take out storm surge insurance with a regular insurance company. However, there is a **public storm surge scheme that can cover storm surge damages** to buildings and building contents (household goods and home furnishings). This scheme is regulated by law and is not a normal insurance policy. Residents pay into the storm surge scheme via a levy on their fire insurance, which is part of their home insurance (so all having a fire insurance contributes to the storm surge scheme).

The insurance companies, while not directly covering the storm surge damage, administer the scheme. Individuals report storm surge damage to their insurers and **the individual insurance companies assess the damages according to the rules of the storm surge scheme** (see below). In terms of what damage costs are covered, the storm surge program generally covers direct damage to buildings and building contents that are covered by the fire insurance. However, there are certain things that the storm surge insurance scheme does not cover, such as items and furniture in the basement or garden. Furthermore, as noted on the website of the scheme, those that live in an area which is flooded frequently, may also not be covered by the scheme.

It is the **Danish Natural Hazards Council (Naturskaderådet)**⁷¹, in collaboration with the **DCA** and the **Danish Meteorological Institute (DMI)**, that decides **when a storm surge is declared, and which geographical areas are covered by the scheme**. This is based on the storm surge water level and the statistics of these. For it to be declared as an extreme event covered by the scheme, the storm surge must be equal to or larger than a **20-year storm surge event**.⁷²

The Danish Natural Hazards Council is an independent council appointed by the Minister of Trade and Industry. It consists of eight members, four experts and a secretariat. It is established in accordance with

⁶⁷ DK Kystdirektoratet (2023)

⁶⁸ Miljøministeriet (2023). 10 projekter deler rekordstor pulje på 150 mio. kroner til kystbeskyttelse <https://mim.dk/nyheder/2023/jan/kystbeskyttelse/>

Executive order no. 1030 of 2 June 2021 on grants from the pool for dikes and other coastal protection, including all terms and conditions for applying for grants www.retsinformation.dk

⁶⁹ From Radikale Venstre, Socialistisk Folkeparti, Enhedslisten and Alternativet

⁷⁰ DK Miljøministeriet (2023a).

⁷¹ <https://www.naturskaderaadet.dk/> In July 2022 Stormrådet changed name to Naturskaderådet (Danish Natural Hazards Council). <https://www.klimatilpasning.dk/aktuelt/nyheder/2022/april/stormraadet-aendrer-navn-til-naturskaderaadet/>

⁷² <https://www.naturskaderaadet.dk/anmeld-naturskade/skade-efter-stormflod-hvad-goer-du/>

laws on certain natural hazards (*“nedsat i henhold til lov om visse naturskader”*).⁷³ The eight council members encompass an independent chairman and seven members who represent insurance companies, citizens, municipalities and ministries. In addition to deciding whether there has been a storm surge, as well as flooding from watercourses and lakes, and drought events, the council also decides on grants for forest restoration after storm damage. Furthermore, **the council supervises and handles complaints about insurance companies’ handling of storm surge cases**, cases of flooding from watercourses and lakes and drought cases. The four experts associated with the council help with technical questions in these processes. The experts have specialized knowledge of coastal conditions, watercourses and lakes, drought and forestry, and they are appointed by the Danish Environmental Protection Agency, the DCA and the Geological Survey of Denmark and Greenland (GEUS), respectively.

3.5 Success Stories and Challenges Related to Sea Level Governance

It can be considered positive that the **national government through the DCA provides all municipalities with map-based data** about their storm surge risks. Municipalities do not have to invest their own resources to retrieve this important information, and by using the same approach everywhere, the national authorities also have control over the quality of the data used. Additionally, the following success stories and challenges were reported during our interviews with informants in Denmark:

- **Capacity building within the municipalities:** the topic of coastal management is one that requires certain legal and technical background. This can be intimidating for some of the municipality employees who process the coastal adaptation projects. Capacity building is continuously being provided by the DCA and KL through guidelines and training courses (see for example Section 3.3.5). These courses have also served as spaces for **facilitating knowledge exchange** among municipality personnel and developing support networks. This has been highly appreciated by municipalities that have limited staff dedicated to the topic due to constrained resources. One issue that is not exclusive to the governance of sea level changes is the **rotation of personnel in the coastal municipalities**. Thus, know-how needs to be constantly created. Rotation of personnel is related for example to early career employees who for personal or job market reasons prefer to move to larger cities in the country.
- Having the **coastal protection role** has given municipalities control over decisions that affect them directly. However, this also presents challenges for municipal authorities when they have to face strong local interests that might oppose the projects (e.g. local politicians or citizens). One way to address this situation has been to have personnel from the DCA joining particular events as they can provide additional technical information and support if needed. Involvement of citizens in the early design phases of the projects (as mentioned in Section 3.2.1) has also been applied as a way to build sense of ownership by the local population.
- Not all coastal adaptation needs to be done today (e.g. no need to build a 4-meter high wall now when this will not be needed before the next 100 years). The DCA has been guiding the coastal municipalities on this approach under the concept of **dynamic adaptation planning**.
- The **social component of adaptation** is something that should be considered more. This specifically refers to segments of the population that experience difficulties with adapting to sea level changes, for example persons with mental or physical disabilities, or elderly people. A new model including this element of the social component has been developed for the national risk assessment under the

⁷³ Naturskaderådet (n.d.). Lovgivning. Gældende regler. <https://www.naturskaderaadet.dk/regler-viden-og-vejledning/regler>

Floods Directive. This has been communicated in conferences and meetings with stakeholders, but it will not be publicly available until summer 2024.

- In the process of planning for climate change adaptation, barriers and challenges can arise if **local citizens and stakeholders are not involved**. Barriers in the process can occur, for example, if there is not the same understanding on the problems and the need for climate adaptation.⁷⁴
- **Compound flooding** (heavy or prolonged rainfall, which results in filled watercourses, combined with storm surge) is increasingly reported as an issue, especially in the Danish fiords where many cities are located (e.g., Vejle, Kolding, Horsens, Randers, and Odense). This issue is a focus at both national and local levels, specifically regarding flood management and climate change. For the municipalities that according to the EU Floods Directive is in a risk area, hazard maps showing combined flooding from the sea and fluvial flooding are available on the webGIS-portal (see Section 3.3.3).
- Related to the **financial aspects of adaptation**, one challenge mentioned with the prioritization of funding for adaptation to coastal flooding towards the west coast (see 3.1) is that limited funds would remain for projects on the inner coasts. Consequently, all the coastal protection costs here would fall on landowners who are meant to protect their own properties (see citizens role in Section 3.2.1).

The literature review for Denmark identified two studies worth mentioning. The first is a study carried out by Madsen et al. (2019) where they explored municipalities' needs for climate information in the light of sea level change. The purpose of the study, conducted by DMI researchers, was to map the needs for coastal climate change information of five municipalities in the Danish southwestern Baltic Sea and the DCA and to develop local climate indicators. The study highlights the **importance of tailored, high-quality climate information for local governments** in coastal areas, particularly for long-term planning and emergency preparedness in the face of climate change. The main findings and outcomes were that:

- Municipalities expressed a strong need for **accurate and detailed** storm surge warnings and projections of extreme sea levels and wave heights. There was a demand for detailed information on mean sea level changes, storm surge heights, wave conditions, and ocean currents. This information needs to be of high quality, with clear reference levels and accompanied by uncertainty measures.
- Municipalities would prefer to **integrate climate information into their current Geographic Information Systems (GIS)** for better decision-making and planning, i.e. the information should be able to integrate into existing systems.
- There was a request for regular **updates of climate information** to aid in planning and decision-making, with a preference for collaborative efforts among municipalities.
- The study led to the development of **targeted climate indicators specific to the needs of the municipalities**. These include indicators for mean sea level change, storm surge, gate index (indicating the frequency and duration of sea level exceedances), sea state changes, and ocean current strength.

The second study was developed by Fitton et al. (2021). The authors investigated the factors influencing the **ability of small towns (less than 10,000 people) to adapt to climate change**. Access to data and knowledge (climate, technical, management), financial resources, as well as local stakeholders' participation and political consensus have an influence on whether larger and smaller municipalities can

⁷⁴Innovativ klimatilpasning i danske kystbyer. Aalborg Universitet 2023. Student Report. By- Energi og Miljøplanlægning 6. semester. Aalborg, Denmark

adapt to climate change. The Danish town of Lemvig was part of the study. Flooding, groundwater and stream flooding, as well as flooding due to storm surges and overflow of sewers in cloud burst events are the biggest concern for Lemvig, and climate change is likely to exacerbate this further. **Key factors** which the authors argue should be considered when developing **management and adaptation strategies for small coastal towns**, are:

- **Local economy:** Highlighting the infrastructure and assets that should be prioritised for protection. Within small towns, the local economy tends to be based on a range of industries, and in some cases a single industry. Disruption of these economic activities will have a proportionally large effect on the town. Protecting the infrastructure that supports this local economy is fundamental for avoiding the situation of reaching a “tipping point” where the infrastructure is irreparably damaged.
- **Data and information access:** Highlighting the importance of having access to information and to analysis of the implications of climate change at the local scale. While data might be available, analysis of implications is generally derived from academic research. Small towns that are part of research networks have the opportunity to acquire expertise and knowledge that they would usually be able to access. The EU Life Coast to Coast project⁷⁵ included partners across municipalities within Denmark.⁷⁶
- **Decision-making:** Highlighting the boundaries of the decision-making process. Questions about how the data are used and how decisions are made and by whom are not only relevant for the population living in the area, but also for those who would be impacted by decisions and responses to coastal and climate hazards. Impacts on neighbouring communities also need to be included, and preferably integrated approaches on joint projects should be executed.

Finally, according to Climate ADAPT (2023)⁷⁷, implementing the EU Floods Directive in Denmark has resulted in a positive impact on raising awareness of flood risk. The **municipalities that have been designated as risk areas are, after two cycles, further ahead in their climate adaptation** compared to other municipalities, partly because of **the requirement to prepare risk management plans**. In the first cycle, in 2011, ten areas effecting 22 municipalities were appointed. In the second cycle in 2018, additional four areas, affecting five municipalities were appointed and two areas were expanded, resulting in 14 areas and 27 municipalities (interviews, Denmark). The statutory framework encourages the municipalities to draw up risk management plans, analyze hazard and risk maps in relation to flooding, set targets for risk reduction, prioritize efforts, identify responsible units, and follow up on implementation plans. Awareness of the consequences of flooding, and willingness to deal with the dilemmas and challenges that climate adaptation entails, as well as to make plans for how the challenges are to be handled, are some of the aspects that municipalities have gained experienced with.⁷⁸

⁷⁵ EC LIFE Public Database (2022). C2C Coast to Coast Climate Change. EU LIFE IP C2C <https://webgate.ec.europa.eu/life/publicWebsite/project/LIFE15-IPC-DK-000006/eu-life-ip-c2c-cc>

⁷⁶ <https://www.c2ccc.eu/>

⁷⁷ Climate ADAPT (2023). <https://climate-adapt.eea.europa.eu/en/countries-regions/countries/denmark> (accessed 10.01.2024)

⁷⁸ Ibid.

4 Governance of Sea Level Changes in the Netherlands

The Netherlands is situated in the **delta** of the rivers Rhine, Meuse, Scheldt, and Ems along the North Sea coast. The coastal region consists of sandy beaches and dunes, estuaries, intertidal areas, and low-lying polders. These polders are densely populated, including the capital Amsterdam, government seat The Hague, and main port Rotterdam. **About 26 percent (10,500 km²) of the Netherlands' territory is below mean sea level, and about 60 percent is vulnerable to floods from the North Sea, rivers, or lakes.** This flood-prone area contains about 60 percent of the population of 17 million and produces about 60 percent of the gross domestic product (GDP) of about EUR 800 billion (Van Alphen, Haasnoot, and Diermanse, 2022).

Because of the large number of inhabitants and high value of assets, the Netherlands has a **high level of flood protection**, provided by a comprehensive system of dams, seawalls, storm surge barriers, dikes, dunes, pumps, sluices, and regular beach nourishments. Two major floods in 1916 and 1953 resulted in closing of the major tidal inlets and estuaries from the sea, which altogether shortened the original Dutch coastline of 1,200 km to about 300 km.⁷⁹ This flood protection and water management system is complemented by a **well-developed governance system** of district water boards, national agencies (*Rijkswaterstaat*⁸⁰), funding, legislation, and well-experienced knowledge institutes and private parties (e.g., dredgers). *Rijkswaterstaat* is the national executive agency of the Dutch Ministry of Infrastructure and Water Management and responsible for the design, construction, management and maintenance of the main storm surge barriers in the Netherlands. In addition, the **water boards** (regional water authorities) are responsible for managing most of the 3,500 km of primary flood defences (especially dikes and dunes). Maintenance and regular upgrading of this flood defence system to changing conditions costs about EUR 1.2 billion annually (Van Alphen, Haasnoot, and Diermanse, 2022).

Without action taken, sea level rise can pose several challenges for the Netherlands (Haasnoot et al., 2020):

- **Increased flood risk:** Sea level rise can increase the risk of flooding from storm surges and high tides, threatening coastal communities, infrastructure, and agricultural land. The Netherlands is traversed by several major rivers, including the Rhine, Meuse, and Scheldt, originating from neighbouring countries, that plays a role in the risk of flooding in the country. Rising sea levels can exacerbate the river flooding. As sea levels rise, the downstream sections of the rivers may experience reduced flow capacity due to the increased water pressure from the sea. This can cause water to accumulate in the rivers and increase the risk of flooding. Storm surges can furthermore cause water to flow back up the rivers, potentially resulting in flooding in coastal areas and along the riverbanks. In the Netherlands, policies require the reinforcement of floods defences when these no longer meet the required standards.
- **Erosion:** Rising sea levels can cause increased erosion along coastlines and riverbanks, potentially damaging infrastructure and altering the landscape. Since 1990, the coastline has been maintained

⁷⁹ The development of the Delta project has a long history; in 1953, the Netherlands suffered from a powerful storm causing an unprecedented tide that led to rises in sea levels, with flooding of 8 percent of the country, more than 1,800 people died, and around 70,000 people evacuated. The event motivated the development of the Delta Project, which aimed to control the area where the mouths of the Rhine and Meuse rivers break into a delta.

⁸⁰ The English name for "Rijkswaterstaat" is essentially the same, as it is often used in its original Dutch form even in English.

by yearly adding sand to the coastal system (sand nourishment). Increasing sea levels require increased sand volumes and nourishment activities.

- **Saltwater intrusion:** As sea levels rise, saltwater can penetrate further inland, contaminating freshwater resources and agricultural land. This can negatively impact water supply and agricultural productivity.
- **Infrastructure challenges:** Existing water management infrastructure, such as levees and storm surge barriers, will need to be upgraded or replaced to cope with higher sea levels and increased flood risk. These improvements are a necessity and build in the current policy system.⁸¹
- **Socioeconomic impacts:** Rising sea levels can result in the displacement of people and businesses, leading to social and economic disruption.
- **Ecological consequences,** such as impacts on the Wadden Sea area. The Wadden Sea is an UNESCO heritage site and the largest system of intertidal sand and mud flats in the world. Sea level rise affects the intertidal surface area of the Wadden Sea through which high levels of sea level rise will eventually lead to drowning of the system by a reduction in flat surface and/or height (Haasnoot et al., 2020; Wang et al., 2018).

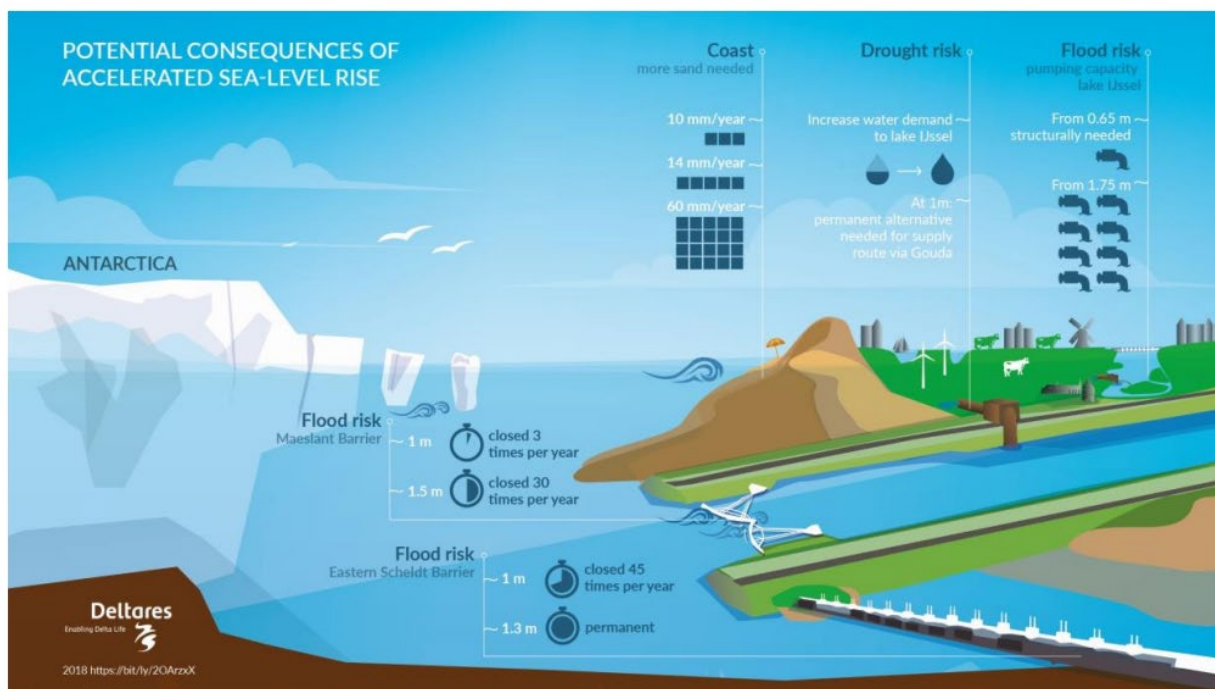


Figure 9. The consequences of accelerated sea level rise for the main elements of Dutch water management. Source: Van Alphen, Haasnoot and Diermanse (2022).

4.1 Climate Change Adaptation in the Netherlands

Climate adaptation policy in the Netherlands is governed by **the National Climate Adaptation Strategy (NAS)** and by **the Delta Programme**. While the NAS provides an overview of all involved and affected policy areas and actions, the Delta Programme addresses more concretely the organization of intergovernmental cooperation and implementation of the sea level governance policies. The realization of the policies is the responsibility of the involved Ministries.

⁸¹ Information provided by informant, November 2023.

Besides the NAS and the Delta Programme, the **National Water Programme (NWP) 2022-2027** is a highly important programme and lays down the current policy for sea level governance, and other aspects related to water management, in the Netherlands.⁸² The NWP describes the general national water policy and management of the national waters and waterways. Through the NWP, the Netherlands also contributes to the implementation of various European Directives. The NWP includes River Basin Management Plans Rhine, Maas, Scheldt and Ems 2022-2027; a Flood Risk Management Plan 2022-2027; Marine Strategy part 3; and a North Sea Programme 2022-2027. These plans are included as legal appendices to the programme.⁸³

The NAS serves as the overarching umbrella policy framework that sets out the overall agenda for climate change adaptation. The Netherlands published its NAS in 2016 and the associated implementation program in 2018.⁸⁴ The Dutch government is in the process of **updating the NAS**, based on the Royal Netherlands Meteorological Institute (KNMI) climate scenarios published in October 2023 (see further section 4.3.3). The new climate scenarios are important input to the forthcoming adapted NAS. A new feature of the updated NAS will be a comprehensive national monitoring scheme for climate adaptation and the Dutch Environment Agency (PBL) has started preparations for the drafting of this monitoring scheme. The new NAS also aims to provide more clarity about the roles and responsibilities of the various involved actors.⁸⁵

The **Delta Programme** is also crucial. The **Delta Programme** deals with adaptation to climate change with a focus on protecting the Netherlands from high water and flooding, freshwater availability, and spatial adaptation. As a result of growing concern about the potential impact of **climate change and sea level rise** on the Dutch delta, **the government initiated this Delta Programme in 2010**. The aim of the Delta Programme is to maintain the Dutch delta as an attractive place to live, work, and recreate for present and future generations, and to protect the country from flooding and ensure a sustainable water supply.⁸⁶

More specifically, the Delta Programme aims at:

- Strengthening and raising dikes and levees.
- Constructing storm surge barriers and floodgates.
- Restoring and preserving natural coastal ecosystems, such as dunes and wetlands, to provide additional protection against flooding.
- Developing innovative water management strategies, such as using multi-functional flood defences and creating more room for rivers.
- Planning for long-term adaptation, including considering future land-use changes and promoting climate-resilient urban development.

⁸² The National Water Programme 2022-2027 is available in Dutch at [Documenten Nationaal Water Programma 2022-2027 | Informatiepunt Leefomgeving \(iplo.nl\)](#) (accessed 20.12.2023).

⁸³ [Summary Draft National Water Programme 2022-2027 \(platformparticipatie.nl\)](#) (accessed 20.12.2023).

⁸⁴ [Uitvoeringsprogramma Nationale klimaatadaptatiestrategie, pdf \(overheid.nl\)](#) (accessed 20.12.2023).

⁸⁵ Under the [current] NAS, plans and actions have been identified, set out in the NAS Implementation Programme 2018-2019. This programme does not specify which party will take up which actions, nor which budget is allocated. See further: Overview of institutional arrangements and governance at the national level" Reporting updated until 2023-03-11. Netherlands-(europa.eu) <https://climate-adapt.eea.europa.eu/en/countries-regions/countries/netherlands> (accessed 4.11.23)

⁸⁶ Deltacommissaris. The 2011 Delta Programme, Working on the Delta; Ministry of Transport; Public Works and Water Management: The Hague, The Netherlands, 2010.

The Delta Act stipulates that a Delta Programme must be drafted annually. The aim is to ensure that the Netherlands is adequately protected against flooding and well adapted to extreme climate effects, and that it has good freshwater supplies. The Delta Act also states that a Commissioner needs to be appointed. The **Delta Programme Commissioner** is the government official responsible for the Delta Programme.⁸⁷ The Commissioner is established for a long-term period and is independent from political dynamics. The Delta Commissioner gives advice to the Parliament with a long-term strategy in mind, to prevent short-term political mal decisions. That is also the main reason for the establishment of the **Delta Fund**; to prevent that short-term priorities interfere with the financing of the long-term climate adaptation strategy.

Currently, the **Flood Protection Programme (HWBP)** is **the largest operational project in the Delta Programme**. The twenty-one water authorities and Rijkswaterstaat are working together in the programme on the largest dike upgrade operation since the Delta Works. The goal of the HWBP is for the primary defences to comply with the flood risk management standards by 2050. That work involves a total of approximately 1,500 kilometres of dikes and more than 400 engineering structures such as locks and pumping stations. A total of 196 kilometres of dikes and 51 structures have now been upgraded or declared safe. Some 100 dike upgrade projects representing 814 kilometres of dikes are planned for 2024-2035. The ambition to upgrade 50 kilometres of dikes each year is expected to be fulfilled by 2026.⁸⁸ Beach nourishment and coast replenishment is a key aspect for coastal protection and for coping with sea level rise and is therefore also a key aspect in the programme.⁸⁹ In the future, a significant acceleration of these activities is needed and foreseen in order to be able to respond to increased sea level rise.⁹⁰

Knowledge related to sea level rise is primarily provided through the **Sea Level Rise Knowledge Programme** (see Section 4.3.2). This programme provides knowledge on how long the current strategies can be maintained and what alternative solutions may be possible and necessary for the Netherlands in the (distant) future. In 2026, this will form the basis for deciding whether the strategies need to be adapted.

Both the National Adaptation Strategy and the Delta Programme call for **integrated action** to manage the risks of climate change on society from all governmental organizations at all levels of governance (Maas and Surian, 2023). Stakeholders are involved in drafting and decision-making, including from the different involved ministries, provinces, municipalities, water authorities, NGO's, industry and citizens.

Overall, the above-mentioned programs demonstrate that **climate change adaptation is not an isolated policy field, but a challenge that affects and crosses many policy areas. Management of sea level rise and storm surges and other aspects related to water management are closely interlinked in the Netherlands**. A lot of policies and measures in the National Water Policy contribute to climate adaptation, and climate adaptation is an important part of flood risk policy. For sea level governance, the government builds upon existing strategies, such as the flood risk approach and the multi-layered safety approach (explained in section 4.2.2).

⁸⁷ <https://www.government.nl/topics/delta-programme> (accessed 20.12.2023).

⁸⁸ <https://english.deltaprogramma.nl/three-topics/flood-risk-management/delta-decision> (accessed 20.12.2023).

⁸⁹ Information provided by informant, November 2023.

⁹⁰ Deltaprogram 2024, available in Dutch only [Deltaprogramma 2024 | Waterveiligheid](#) (accessed 20.12.2023).

Currently, spatial pressure is very high in the Netherlands, and both water and soil are reaching their boundaries in terms of which services these ecosystems can provide for.⁹¹ Since November 2022, **Soil and Water** have therefore become the **guiding principles** for all policy decisions related to spatial planning and decision-making.⁹² Three key guidelines are formulated:

1. **Do not pass on the burden to future generations.** This means taking into account pressures on soil and water, climate change and future management costs now. For example, treating the soil properly now will ensure that the soil remains suitable for growing crops for future generations.
2. **Do not pass on the burden to other areas or functions.** This means an action at one location (such as buildings, groundwater extraction or use of plant protection products), must not lead to an unintended effect elsewhere (flooding, desiccation of nature reserves or water pollution). Because impacts on other areas or functions is often unavoidable, certain exceptions to this should remain possible. However, the different interests need to be weighed appropriately.
3. **Do not pass on the burden from private to public.** This means, among other things, that investments take sufficient account of climate change, subsidence, soil and water pollution and natural water storage capacity of the soil, and the costs associated with it. By paying attention to costs of the entire life cycle, as much as possible value for the money invested should be ensured. Not just value for today, but also for tomorrow.⁹³

In addition to these three overarching guiding principles, 33 structuring choices and 58 measures have been announced. These relate to sufficient water, clean and healthy water, soil, build environment, low lying peat areas, salinization of coastal areas, and higher sandy soils.⁹⁴ This strategic prioritization is also important for sea level governance in the Netherlands.

4.2 Governance Arrangements for Managing Sea Level Changes

4.2.1 Actors, roles, and responsibilities in sea level governance (at various levels)

Several actors are involved in sea level governance in the Netherlands. Most importantly, and at the national level; the Delta Program Steering Group and Commissioner, the Ministry of Infrastructure and Water, Rijkswaterstaat, and the Royal Netherlands Meteorological Institute (KNMI).

At the **national level**, the **Delta Programme Steering Group** provides administrative embedding and recommendations for the Delta Commissioner. **The steering group includes directors of the umbrella organisations of provincial and municipal authorities, and water authorities, the chairs of the area consultation platforms and the directors-general of the ministries concerned.** The ministries are:

- the Ministry of Infrastructure and Water Management (including Rijkswaterstaat)
- the Ministry of the Interior and Kingdom Relations
- the Ministry of Agriculture, Nature and Food Quality

⁹¹ [Kamerbrief over rol Water en Bodem bij ruimtelijke ordening | Kamerstuk | Rijksoverheid.nl](#) (accessed 20.12.2023).

⁹² [Coalitieakkoord 2021 – 2025: Omzien naar elkaar, vooruitkijken naar de toekomst \(overheid.nl\)](#), p.13.; [Grote opgaven in een beperkte ruimte \(pbl.nl\)](#) (accessed 20.12.2023).

⁹³ Letter to Parliament about the role of Water and Soil in spatial planning, 25 November 2022. Available in Dutch at: [pdf \(overheid.nl\)](#). See also [Kabinet maakt water en bodem sturend bij ruimtelijke keuzes - Klimaatadaptatie \(klimaatadaptatienederland.nl\)](#). (accessed 20.12.2023)

⁹⁴ Ibid.

- the Ministry of Economic Affairs and Climate Policy

The Delta Commissioner chairs the Delta Programme Steering Group.⁹⁵

The Ministries of Infrastructure and Water Management; the Interior and Kingdom Relations; and Agriculture, Nature and Food Quality also work together in drawing up the **National Water Program**. They developed this program together with other authorities, drinking water companies, social organizations and industry and sector parties. Collaboration is crucial to meet the challenges surrounding water.

Of all ministries, **the Ministry of Infrastructure and Water Management** is politically responsible for water safety, determining standards for 'primary' flood defences, providing technical instruments, and regulating the functioning of the policy area as a whole. Most flood defences are administered by regional water authorities, while some flood defences, e.g. **storm surge barriers**, are under the **responsibility of the national authority** and Rijkswaterstaat (the executive agency of the Dutch Ministry of Infrastructure and Water Management).

The water managers are responsible for its maintenance and reinforcement whenever necessary to meet standards. To illustrate, water managers may need to report the dike to the **Flood Protection Program [HWBP]** when it fails to meet the standards. The Flood Protection Program prioritises projects according to their urgency, and schedules within the available budget from the Delta Fund. There will be an administrative discussion with the regions about the proposals; if requested and possible, the improvements can be combined with other initiatives and financing. This will be updated annually.⁹⁶ A first **National Assessment Round** for the primary defences was initiated in 2017. A set of statutory instruments is available for the assessment. This is a package of agreements and methods for the assessment of the primary defences. That assessment was completed in 2022 and found that a majority of primary flood defences do not yet comply with the standards for flood risk management.⁹⁷

The national **Rijkswaterstaat** is a key actor in the implementation of the National Water Policy and the Delta Programme. Rijkswaterstaat is responsible for the design, construction, management and maintenance of the Netherlands' primary infrastructure facilities. One of the priorities is protecting the Netherlands' vulnerable low-lying regions.⁹⁸ As the network manager, Rijkswaterstaat has the responsibility to act in a climate-proof manner from 2020 and to have the networks climate-proofed by 2050. Therefore, Rijkswaterstaat is working on (research into) climate resilience in line with the goals in the Delta Programme and the National Climate Adaptation Strategy. The institution is working towards making climate resilience a given in management and maintenance, as well as for new constructions, replacements, and renovations. Climate adaptation needs to be implemented from the start until the end and is an important issue in policy assignments, frameworks and project guidelines.

⁹⁵ [Organisation | Delta Programme | Delta Programme \(deltaprogramma.nl\)](#) (accessed 20.12.2023).

⁹⁶ Information from informant, November 2023.

⁹⁷ [Beoordelingsronde 2017 - 2023 - Helpdesk water](#). The full assessment itself does not appear to be publicly available.

⁹⁸ <https://www.rijkswaterstaat.nl/en/expertise/climate-adaptation> (accessed 7.11.2023).

Rijkswaterstaat has constructed six imposing storm surge barriers to protect the country from flooding (Figure 10). If the water level rises to a dangerous level, the barriers close. The water is then prevented from flowing inland via rivers or estuaries. The storm surge barriers are important defences, since climate change is causing sea levels to rise, and the Netherlands expect to be increasingly confronted with high water levels.⁹⁹ Storm surge barriers are preferred over dams due to the need to allow for the free navigation of shipping.



*Figure 10. Example of a storm surge barrier.
Source: Delta Works | Rijkswaterstaat.*

During **the planning period**, the influence of flooding, heat, drought and flooding on the performance and functioning of the networks is assessed, quantified and visualized by means of ‘**stress tests**’. Such tests are performed on the national and regional level by Rijkswaterstaat and the regional water boards. Risk dialogues are then conducted, and an implementation agenda is drawn up. In this implementation agenda, an overview is given of the climate adaptation measures for the government networks. Risk dialogues are conducted, and measures are determined in cooperation with the policy actors within **the Ministry of Infrastructure and Water Management**, who determines the climate resilience ambition.¹⁰⁰

The Royal Netherlands Meteorological Institute (KNMI) is legally obliged to provide observations on atmospheric, oceanic, and terrestrial indicators, including data on expected extreme weather conditions. Vulnerability assessments are generally realised through national studies and European research projects. The KNMI also translates the IPCC scenarios to **new climate scenarios** for the Netherlands. The most important national efforts include reports from the Delta Programme, The Netherlands Environmental Assessment Agency (PBL) and the Knowledge for Climate programme.¹⁰¹ **Rijkswaterstaat** also has a programme on climate resilient networks. In the context of this programme, Rijkswaterstaat works together with several partners, to examine the impact climate change has on the main roads, rivers, and canals in the Netherlands and to identify possible solutions.

In addition to the actors mentioned above, also lower-level governance actors are important in the Netherlands. The core of the Delta Programme is **a national approach, with room for regional interpretation** and the involvement of all parties. The national government, provincial and municipal authorities and water authorities have **shared responsibility and shared ownership**. The regional administrative alliances of the government authorities are of major importance for the discussion of the delta agendas in conjunction with other area agendas. The scope of the agendas and their elaboration varies from area to area and so administrative engagement also varies depending on the region and theme in question. See further section 4.5 for the role of regional authorities.

⁹⁹ [Storm surge barriers | Rijkswaterstaat](#) (accessed 20.12.2023).

¹⁰⁰ The National Water Programme 2022-2027 is available in Dutch at [Documenten Nationaal Water Programma 2022-2027 | Informatiepunt Leefomgeving \(iplo.nl\)](#), p.134

¹⁰¹ <https://climate-adapt.eea.europa.eu/en/countries-regions/countries/netherlands> (accessed 20.12.2023)

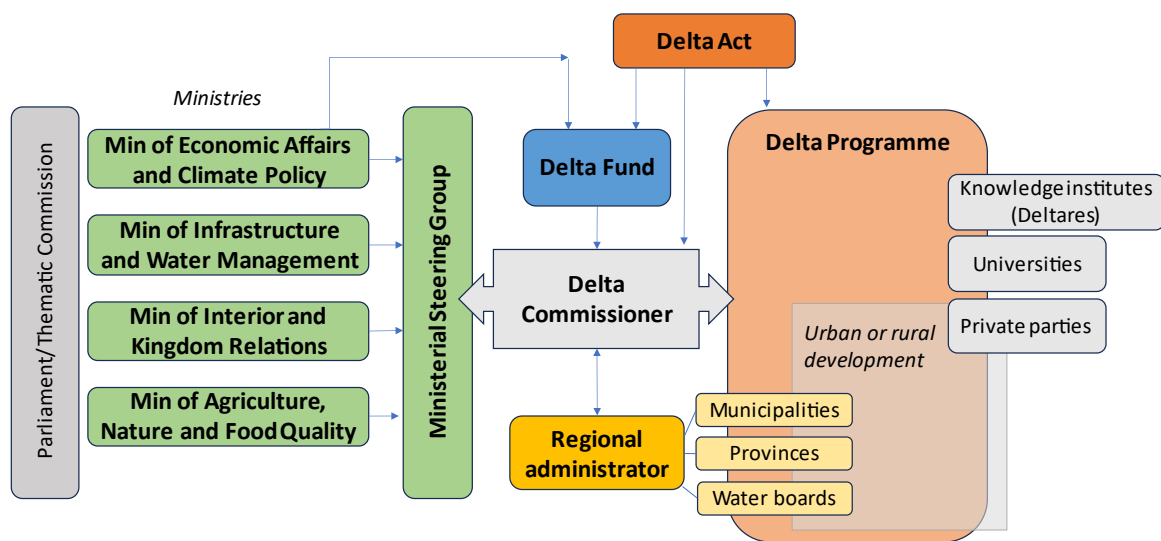


Figure 11. Actors involved in sea level governance in the Netherlands. Adapted from Bisaro 2020.

Since the launch of the **Delta Programme**, the national government, water authorities, and provincial and municipal authorities have been working together in an innovative way with input from knowledge institutes, stakeholder organisations, business and citizens. Work within the Delta Programme covers three thematic areas: Flood Risk Management, Fresh Water and Spatial Adaptation. The three agendas of the Delta Programme have specific, logical, regional boundaries with a corresponding administrative agenda, with the authorities concerned organising support arrangements. The main tasks involve the **implementation and further elaboration of the Delta Decisions** and preferred strategies, **informing the Delta Commissioner** about progress and **submitting recommendations** about the annual proposal for the Delta Programme.

The three themes and the joint approach is implemented in national and regional contexts. In 2014, representatives of the provincial and municipal authorities, the water authorities and the Minister of Infrastructure and Water Management signed the ‘**administrative agreement for the Delta Programme**’.¹⁰² Under the agreement, the government authorities agree to take the **Delta Decisions and preferred strategies into account in their own plans.**¹⁰³

On the matter of **wave attacks** within the context of sea level governance, this is approached rather technically. To illustrate, the hydraulic loads that are taken into consideration are locally specific and always a combination of water level and wind conditions. For levees, hard structures and sandy coast/dunes, different calculations are applied. Basic 'calculating rules' to use to calculate strength of / design a structure are being provided by the Ministry of Infrastructure and Water Management. It thus appears that the impacts of wave attacks are specifically taken into consideration in the assessment of the resilience of existing levees and other barriers.¹⁰⁴

¹⁰² Deltaprogramma Bestuursvereenkomst Deltaprogramma Boring deltabeslissingen en voorkeursstrategieën.

¹⁰³ [What is the National Delta Programme? | Delta Programme | Delta Programme \(deltaprogramma.nl\)](https://deltaprogramma.nl/) (accessed 20.12.2023)

¹⁰⁴ Information from informant. More information is available on <https://jpl.nl/thema/water/waterveiligheid/> (in Dutch only). The website gives an overview of all information. For information about wave attacks, search for 'golf' or 'golven'.

4.2.2 Key policies, programs, and planning guidelines for sea level governance

As mentioned above, the **National Water Program (NWP)** is an important mechanism through which the Netherlands complies with several European directives. In an integrated manner, the program covers requirements and measures related to river basin management plans based on the Water Framework Directive (**WFD**); the flood risk management plan based on the Flood Risk Directive (**Flood Risk Directive**); and The North Sea Program on the basis of the Marine Strategy Framework Directive (**MSFD**) and Maritime Spatial Planning Framework Directive (**MSPD**).¹⁰⁵ **Climate adaptation is a new theme in this NWP**. During the last planning period (2016-2021), the importance of this subject has increased significantly, and policy and implementation has expanded.

In legal terms, pursuant to the **Dutch Water Act**, the NWP is considered as the ‘national water plan’ that needs to be **revised every six years**. The NWP is self-binding for the government. The government asks lower-level governmental authorities to translate NWP into their regional (water) plans.¹⁰⁶ Thus, in the NWP, the central government sets the framework for national water policy and its implementation of this for the main water system and the main waterway network. The provinces set the framework for the regional water system. They set environmental visions and programs (including one regional water programme). Water boards elaborate this in their water management programs and municipalities in their environmental vision. These frameworks are conducted at the same time, and therefore require a delicate process of cooperation.

The government also works intensively on the implementation of the **Delta Programme**. Legally speaking, the Delta Programme is an annual proposal of the Delta Commissioner for the focus on water safety, freshwater supply and spatial adaptation, that is offered to the Ministry of Infrastructure and Water management in accordance with Article 4.10, first paragraph of the Water Act. The Minister offers the annual Delta Programme to the Parliament.

The Delta Act stipulates that a Delta Programme must be drafted annually. The aim is to ensure that the Netherlands is adequately protected against flooding and well adapted to extreme climate effects, and that it has good freshwater supplies. The Act also stipulates that there must be a Delta Commissioner to direct the drafting and implementation of the Delta Programme. It also provides for a Delta Fund as one source of financing for the Delta Programme.

Important governance principles for sea level changes

Sea level governance is characterised by several key principles or approaches, including a **risk-based** approach combined with a **multi-layer safety** approach; the **solidarity** principle; and an **adaptive** governance approach.

Risk-based approach

Since the publication of **the Delta Programme and Delta Decisions** in 2015, policy for **flood risk management has made the switch to a ‘risk approach’**. The core of **the Delta Decision for Flood Risk Management** is that, by 2050 at the latest, the probability of mortality as a result of flooding for everyone behind the dikes will not exceed 1 in 100,000 per year (or 0.001 percent). This is the ‘base protection level’. The protection level is higher in locations where the potential impact is very high, for example if

¹⁰⁵ The National Water Programme 2022-2027 is available in Dutch at [Documenten Nationaal Water Programma 2022-2027 | Informatiepunt Leefomgeving \(iplo.nl\)](#). (accessed 20.12.2023).

¹⁰⁶ Ibid, p.14

there is a risk of large numbers of casualties, extensive economic damage and/or damage to vital infrastructure of national importance.¹⁰⁷

The risk-based approach links the level of protection to both the probability of flooding and its consequences. It is stated that this approach allows the arrangements for flood risk management to be more efficient and effective. **The risk approach and the new standards associated with it have been included in the Water Act since 2017.**¹⁰⁸

The risk-based approach is combined with a **multi-layer safety** approach. The multi-layer safety approach was introduced in 2009 in the Netherlands as a result of the shift from flood prevention to flood risk management. It aims at reducing flood risks by integrating defensive measures against floods (layer 1), resilient spatial planning measures (layer 2), and effective disaster management measures (layer 3) (Bosoni, Tempels and Hartmann 2021). Recently though, the layers have expanded towards five layers, where the aim is firstly to 1) raise awareness about sea level rise; 2) protect against it; 3) reduce society and communities' vulnerability to it; 4) evacuate when risk is materializing; 5) recover from the event. The first and last layer have thus been added to the original three layers.¹⁰⁹

Between 2015 and 2023, considerable progress was made on the implementation of the **Delta Decision for Flood Risk Management**. The protection objectives have been **formulated as standards for the primary flood defences**: the dikes, dunes, dams and storm surge barriers that protect the Netherlands against flooding from the sea, as well as from the large rivers and the large lakes.¹¹⁰

Adaptive governance approach and adaptive pathways

The Delta Programme has a long-term time horizon, up to 2100. To make the inherent uncertainty in climate and socio-economic developments manageable, an adaptive approach has been adopted, including scenarios, adaptive strategies, and **periodic (every 6 years) review** (Bloemen et al., 2019, p. 321–351). A **'Signal' group** of independent experts (see section 4.3.4) advises the Delta Commissioner on **an annual basis** on relevant new aspects. These aspects will be more thoroughly described below. The Delta decisions, taken as part of the Delta Programme, are incorporated in the National Water Programme (NWP).¹¹¹

Key aspects of **adaptive Delta governance** are 1) to connect decisions made now with long-term agendas in the areas of flood risk management and fresh water; 2) to ensure that solutions are flexible; 3) to have multiple strategies ready and ensuring the Netherlands can switch track quickly if circumstances change (adaptation pathways); 4) to connect investments in flood risk management and fresh water with investments in areas such as spatial planning and nature, and making redevelopment water-robust and climate-resilient where possible.¹¹²

¹⁰⁷ [Delta Decision for Flood Risk Management | Three topics | Delta Programme \(deltaprogramma.nl\)](#). (accessed 20.12.2023)

¹⁰⁸ Ibid.

¹⁰⁹ Ministry of Infrastructure and Water Management (2022). Kamerbrief over rol Water en Bodem bij ruimtelijke ordening. Tweede Kamer, vergaderjaar 2022–2023, kenmerk IENW/BSK-2022/283041. Den Haag: Sdu uitgevers; See also this report: [Voorbij de dijk | Rapport | Algemene Rekenkamer](#) (accessed 20.12.2023).

¹¹⁰ [Risk-based-standards-for-Flood-Defences.pdf \(researchgate.net\)](#); [Delta Decision for Flood Risk Management | Three topics | Delta Programme \(deltaprogramma.nl\)](#) (accessed 20.12.2023)

¹¹¹ [What is the National Delta Programme? | Delta Programme | Delta Programme \(deltaprogramma.nl\)](#) (accessed 20.12.2023)

¹¹² [Adaptive delta management | Delta Programme | Delta Programme \(deltaprogramma.nl\)](#); Bloemen et al., (2019).

To adapt to uncertain climate change, the Netherlands thus follows an **adaptive approach with short-term actions and long-term options to be implemented depending on how the future unfolds**. (Van Alphen, Haasnoot, and Diermanse (2022); Haasnoot, Warren and Kwakkel (2019). Key is to maintain various alternatives open depending on how quickly sea level rise happens.

Adaptive Delta Management is a term coined by the Delta Programme for ‘*addressing uncertainties in a transparent way*’.¹¹³ While it is recognised that there are significant uncertainties about the rate and extent of climate change and socio-economic developments, there is also an urgent need to make decisions about (small or large scale) infrastructure investments. Achieving this objective, however, requires an approach that considers different investments from the perspective of the uncertainties, but is flexible enough to adapt the strategy to unexpected challenges and opportunities in the future.

Four main adaptation pathways are considered (Figure 12) and each of these will trigger a number of measures if certain thresholds are reached (Figure 13). More concrete building blocks with measures have been developed on the basis of these pathways (Haasnoot et al., 2019).

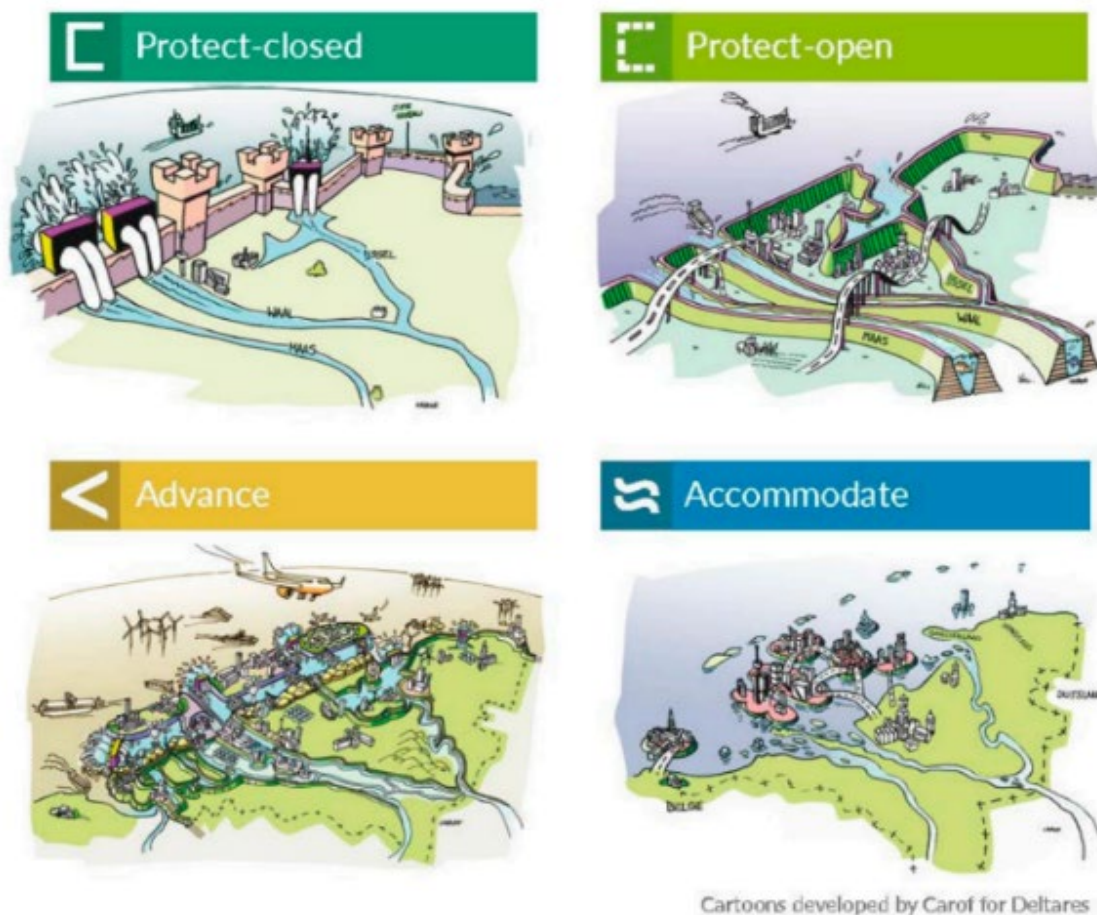
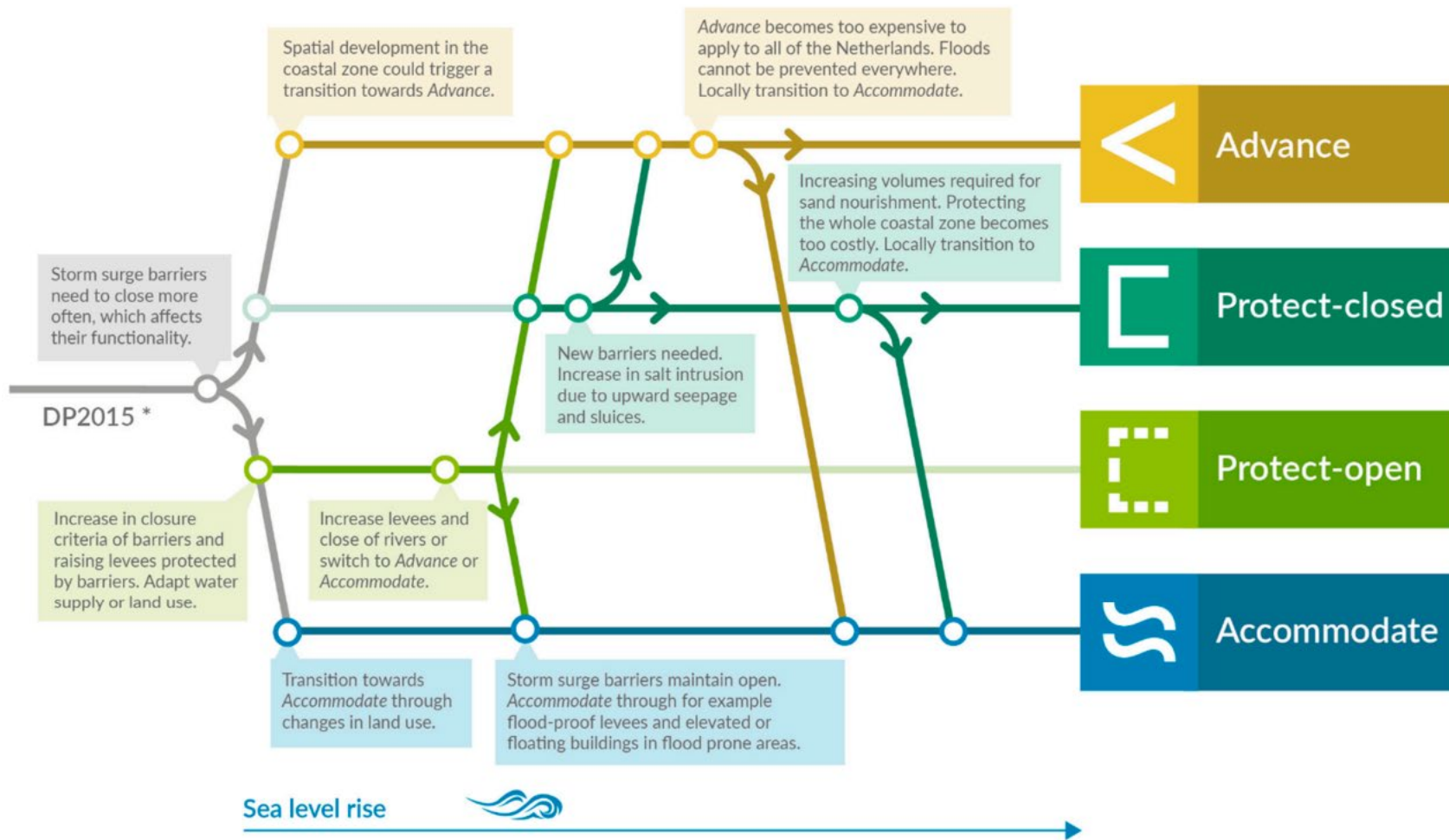


Figure 12. Four adaptation pathways. Source: Van Alphen, Haasnoot and Diermanse (2022), based on Haasnoot et al, (2019).

¹¹³ <https://www.stowa.nl/deltafacts/waterveiligheid/delta-facts-english-versions/delta-scenarios-and-adaptive-delta> (accessed 20.12.2023)



*) Decisions and strategies presented in the Delta Program 2015

Figure 13. Four adaptation pathways with measures. Source: Van Alphen, Haasnoot and Diermanse (2022), based on Haasnoot et al., (2019).

Under the ‘Protect’ pathway, the Government would continue the present policy to preserve the territory of the Netherlands by increasing volumes of beach nourishments and raising dikes and seawalls. Under the ‘**protect-closed**’ strategy, the estuaries are closed off from the sea completely by dams, navigation locks, and sluices. In this ‘**protect-open**’ strategy, rising sea level extends its influence upstream along the rivers, flooding unembanked (harbour) areas and requiring extensive dike improvement programmes to maintain flood protection standards. The ‘**accommodate**’ strategy is based on the ‘living with water’ concept. For the Dutch delta, this could be a combination of ‘retreat’ (‘relocate’, horizontal retreat) and ‘accommodate’ (vertical retreat, by creating mounds, raising buildings, or creating ring dikes to protect urban areas and reduce vulnerability, or by introducing floating solutions). In this strategy, flood defences are maintained to the present height, but not raised to rising sea level. As a result, low-lying areas may experience more frequent flooding (e.g., from presently 1:10.000 to 1:10 years in the future). This strategy may have a large societal impact since large parts of the country must be re-organized or abandoned and millions of inhabitants must adapt or migrate to higher ground. The ‘**advance**’ (‘**fight**’) strategy is new compared to the original IPCC types, though it also was included in the most recent IPCC report (Glavovic et al., 2022). In this strategy, the present coastline is extended seaward to build a more robust coastal flood defence. It can be considered as a special kind of protect strategy, also creating 100–500 km² of new land.¹¹⁴

The different strategies have very different implications, but the rationale behind the adaptive pathways is that the uncertainty in the speed of sea level rise necessitates the existence of multiple options to maintain flexibility in the future. It also helps to break adaptation in to manageable steps and identify what these long-term strategies mean for the near-term future and determine the pivotal decisions. Spatial planning is, for example, key to long-term adaptation (Haasnoot et al., 2019, p.9-10).

The solidarity principle

Solidarity in the context of climate change adaptation and sea level changes implies that the risks and burdens that society faces should be shared by the group as a whole, that is, all inhabitants of the Netherlands (Dawson and Verweij, 2012). As such, it implies a (re)allocation of individual flood risk burdens to the collective which is institutionalised into the flood risk management approaches. It also has implications for the funding of adaptation to sea level changes and is therefore discussed further in Section 4.4.

As described above, the Delta Programme is key in sea level governance in the Netherlands, and knowledge is central to the program. The **Delta Programme is devoting a great deal of attention to applying, developing and sharing knowledge.**¹¹⁵

4.3 Knowledge Base related to Sea Level Changes

4.3.1 The Delta Scenarios

Sea level rise has consequences for the entire water system, as it affects sand nourishments, storm surge barriers, water discharge from rivers, lakes, canals and streams, and salinization. The sea levels will continue to rise, but how quickly and by how much is unclear. **The Delta Programme looks ahead to 2050 and 2100 and outlines possible futures.** What will the climate be like throughout the century? And which

¹¹⁴ <https://www.stowa.nl/deltafacts/waterveiligheid/delta-facts-english-versions/delta-scenarios-and-adaptive-delta> (accessed 20.12.2023).

¹¹⁵ <https://english.deltaprogramma.nl/delta-programme/knowledge-development> (accessed 20.12.2023).

socio-economic developments can be expected in the coming decades? Working with different visions of the future ensures that the Netherlands is well prepared.¹¹⁶

The **Delta Scenarios** provide qualitative and quantitative information about the climate, water systems, water use and land use. The qualitative information consists of storylines and maps.¹¹⁷ The quantitative data consist of indicators and time series for factors like temperature, precipitation, land subsidence and salinisation. The scenarios are based on two factors of significant impact on water issues, which are simultaneously highly uncertain; **climate change and socio-economic development**. It should be noted that the Delta Scenarios are neither predictions nor target scenarios. Rather, they are context scenarios that show how climatic and socio-economic context may change for water management by 2050 and 2100.

The **Delta Scenarios explore four different types of future situations**, which can be used to determine where and when alternative (water) measures will be required in the future. The four Delta Scenarios are called: *Steam, Busy, Warm and Rest*. The aim is that the Delta Scenarios can be used to identify future water-related issues, assess measures and trigger more insights to inspire new strategies. They are **part of the Adaptive Delta Management cycle** (see Section 4.2.2).

4.3.2 Sea Level Rise Knowledge Program

According to the IPCC report published in August 2021, increasingly more signs indicate that **the sea level may rise at a pace faster than assumed in the Delta Scenarios**. In 2016, Deltares started exploring, in anticipation of the IPCC report, how this could impact the **Delta Programme** and did a follow-up study as an assignment for the Delta Programme that was published in 2018 (Haasnoot et al., 2018).

Subsequently, in 2019, the Minister of Infrastructure and Water Management and the Delta Programme Commissioner jointly initiated **the Sea Level Rise Knowledge Programme**. Under this programme, government authorities, research institutes, businesses, planners, and NGOs are pursuing new expertise on the potential rise in sea level: its pace and its scope; the consequences for flood defences systems, freshwater supply, and spatial planning; and ways to anticipate such consequences in good time.

The **Sea Level Rise Knowledge Program** will provide more insight in the coming years to indicate the sustainability of current strategies.¹¹⁸ The knowledge program will also help to give direction to choices for the medium and long term, or to choices that are short-term and should be avoided because they can become obstacles in the longer term.

The program aims to improve the mechanisms that accelerate sea level rise to understand the sustainability of current strategies for water security and freshwater supply and the options to investigate the long term. In 2023, a report was published on the so-called '**Duidingskader strategieën zeespiegelstijging**' [**Explanation framework strategies sea level rise**]. The framework provides an instrument to test the sustainability of, and compare, different strategies under a certain sea level rise. The focus of the report is long-term to very long-term zooming in on sea level rise levels between 0.5 and 5 meters.¹¹⁹

¹¹⁶ [Delta Scenarios | Delta Programme | Delta Programme \(deltaprogramma.nl\)](#) (accessed 20.12.2023).

¹¹⁷ <https://www.stowa.nl/deltafacts/waterveiligheid/delta-facts-english-versions/delta-scenarios-and-adaptive-delta> (accessed 20.12.2023).

¹¹⁸ [Kennisprogramma Zeespiegelstijging | Deltaprogramma | Deltaprogramma](#) (accessed 20.12.2023).

¹¹⁹ [Duidingskader strategieën zeespiegelstijging | Publicatie | Deltaprogramma](#) (accessed 20.12.2023).

The knowledge program explores how long the current strategy will last and also which alternative solutions are possible for the Netherlands in the (distant) future. The aim is to provide the coming generations with **a basis for a water-safe future, but not to prescribe these in detail**. That is why the aim is to make decisions where necessary, but also with the possibility to keep longer term solutions open. In concrete terms, this means that spatial developments that require space, must be taken into account in the long term to maintain the Netherlands safe and liveable, for example, by keeping space free around barriers and outside the dikes to take future water levels into account.

The insights provided through the knowledge program in the coming years will help the government to assess whether policy changes are needed in the short term. In addition, the insights provided by the parties involved in the Delta Programme will be used for the recalibration of the delta decisions and preferential strategies in 2026. The results of the program will thus become available in 2026, to give input to the next 6-year evaluation of the Delta Programme. Preparations are being made to **expand the program into a long-term monitoring program**, focusing on the impacts of climate change on all relevant sectors, on policy effectiveness and on the implementation of measures.¹²⁰

All in all, sea level rise scenarios thus come from KNMI. Impacts and adaptation options are developed through the knowledge program on sea level rise and by knowledge institutes such as Deltares and/or universities.¹²¹

4.3.3 Climate scenarios: KNMI'23 climate scenarios

There is growing evidence that sea levels may be rising faster than previously expected in the Delta Scenarios.¹²² The probability of severe rainstorms and prolonged drought would also appear to be higher than previously assumed.¹²³

The **effects of climate change** lead to higher pressure on the water systems; higher river discharges and sea level rise increase the task of bringing flood defences up to standard to comply. **So far, the government has taken into account a maximum sea level rise 0.45 meters in 2050 and a maximum of 1 meter around 2100.**¹²⁴ However, there is great uncertainty about the speed and extent of sea level rise.¹²⁵ In 2014, the Delta Commissioner proposed strategies and measures to prepare for climate change, related to a 1.5 and 3.5 °C global warming scenario and anticipating a sea level rise of 0.3–1.0 m in 2100 (relative to 1990).¹²⁶ This was in line with the most recent national climate change scenarios of the Royal Dutch Meteorological Institute at the time, which were based on the Fifth IPCC Assessment Report.¹²⁷ In

¹²⁰ The National Water Programme 2022-2027 is available in Dutch at [Documenten Nationaal Water Programma 2022-2027 | Informatiepunt Leefomgeving \(iplo.nl\)](#), p.52. (accessed 20.12.2023).

¹²¹ Information from informant.

¹²² [KNMI'23 Klimaatscenario's voor Nederland](#) (accessed 20.12.2023).

¹²³ Ibid.

¹²⁴ KNMI climate scenarios 2014, NWP 2016-2021.

¹²⁵ The National Water Programme 2022-2027 is available in Dutch at [Documenten Nationaal Water Programma 2022-2027 | Informatiepunt Leefomgeving \(iplo.nl\)](#), p.62. (accessed 20.12.2023).

¹²⁶ Deltacommissaris. The 2015 Delta Programme, Working on the Delta. The Decisions to Keep the Netherlands Safe and Liveable; Ministry of Infrastructure and the Environment: The Hague, The Netherlands, 2014.

¹²⁷ Royal Dutch Meteorological Institute KNMI. KNMI'14 Climate Scenarios for the Netherlands; A Guide for Professionals in Climate Adaptation 2015; Available online (accessed 20.12.2023):

<https://www.knmiprojects.nl/projects/climate-scenarios/documents/publications/2015/01/01/brochure-knmi14-climate-scenarios>

2017, the Signal Group advised the Delta Commissioner to pay more attention to a possible acceleration of sea level rise and its potential consequences for the Dutch delta.¹²⁸

In **October 2023**, the KNMI published **new climate scenarios**, based on the very latest global climate insights and IPCC report. These **KNMI'23 climate scenarios** consist of four paths that describe a possible future climate in the Netherlands around **2050, 2100 and 2150**.¹²⁹ They describe, among other things, changes in temperature, precipitation, drought, wind and sea level rise, and show observed trends and 30-year weather ranges that fit the future climate. Some of the updates and improvements of KNMI'23 compared to its predecessor KNMI'14 is an explicit separation of wet/dry scenarios, more information on probabilities associated to sea level rise, a stronger underpinning of changes in summer precipitation and temperature extremes, coupling to SSP/RCP scenarios¹³⁰, and longer time horizons, up to 2300.¹³¹

For sea level rise, a specific outlook is given for the period after 2100 up to 2300. Also, additional estimates for the highest possible sea level rise (low probability, high impact) are included in the KNMI'23. The melting of the Greenland Ice Sheet contributes relatively little to the sea level rise off the Dutch coast. Sea level in the Netherlands in the far future will be almost entirely determined by the speed at which the Antarctic Ice Sheet expands loses mass. According to the high emissions scenario in the KNMI'23, **sea level rise around 2300 will be between 2 to 6 meters.** If also uncertain ice sheet processes in Antarctica are taken into account, this can amount to more than 17 meters. An acceleration may unfold especially in the second half of this century.¹³²

A recent publication by Van de Wal et al. (2022) calculated possible sea level rise high-end scenarios. For global warming of +2°C in 2100 (RCP2.6/SSP1-2.6) relative to pre-industrial values their high-end global sea level rise estimates are up to 0.9 m in 2100 and 2.5 m in 2300. Similarly, for a global warming of +4°C in 2100 (RCP8.5/SSP5-8.5), they estimate sea level rise up to 1.6 m in 2100 and up to 10.4 m in 2300.

The scenarios form input for water safety policy, the Sea Level Rise Knowledge Programme, the Delta Programmes for Freshwater and Spatial Adaptation and the NAS. The new climate scenarios may also cause adjustments to previously made policy choices.¹³³ More specifically, the KNMI'23 climate scenarios are used in the following programs and products:

- The Sea Level Rise Knowledge Program conducts research into the possible consequences of sea level rise for NL and how to prepare for it.
- The Flood Protection Program is responsible for dike reinforcement.
- The delta scenarios are expected to be ready by the end of 2024 and form the basis for water supply, water management and discharge calculations for water boards.

¹²⁸ Deltacommissaris. The 2018 Delta Programme, Continuing the Work on a Sustainable and Safe Delta; Ministry of Infrastructure and the Environment: The Hague, The Netherlands, 2017.

¹²⁹ <https://www.knmi.nl/kennis-en-datacentrum/achtergrond/knmi-23-klimaatscenario-s> (accessed 20.12.2023).

¹³⁰ The 2023 Climate Scenarios are based on a direct connection with low and high emissions: SSP 1-2.6 (associated with the Paris Climate Agreement) and SSP 5-8.5. This differs from the 2014 scenarios, which were based on moderate and high emissions: RCP4.5 and RCP8.5. See further [KNMI'23 Klimaatscenario's voor Nederland](#) (accessed 20.12.23).

¹³¹ https://cdn.knmi.nl/system/data_center_publications/files/000/071/903/original/KNMI23_climate_scenarios_final_assessment_WR23-02a.pdf . (accessed 20.12.232023).

¹³² [KNMI'23 Klimaatscenario's voor Nederland](#) (accessed 20.12.2023).

¹³³ The National Water Programme 2022-2027 is available in Dutch at [Documenten Nationaal Water Programma 2022-2027 | Informatiepunt Leefomgeving \(iplo.nl\)](#), p.52 (accessed 20.12.23).

- The discharge scenarios are important for calculations in the Delta Program; higher discharges are relevant for flood risk policy; Long-term low river discharges are relevant for the freshwater supply and the navigability of the rivers.¹³⁴
- The Climate Scenarios are used as input for the stress tests of the Delta Spatial Adaptation Program.
- The Climate Adaptation Knowledge Portal provides an overview of information for everyone working on climate adaptation. The Themes and Sectors page brings together information about the impact of climate change on various sectors.
- The Map Viewer - Climate Impact Atlas¹³⁵ The Climate Impact Atlas helps to gain a basic impression of how climate change will impact one's own area. The Atlas comprises a Viewer and Map Narratives. The Atlas has adopted the same climate impact categorisation as the Delta Plan on Spatial Adaptation, using a four-theme structure: flooding, waterlogging, drought, and heat. In addition to providing a basic impression of how the changing climate may affect the Netherlands, now and in the future, the Atlas also contains context maps, such as soil maps and maps indicating potential opportunities. The zoom feature enables users to zoom in on their own municipality.¹³⁶
- The National Climate Risk Analysis identifies the risks for the Netherlands in the current climate (report expected in 2024) and in the future climate (report expected in 2026).

4.3.4 Additional activities related to the knowledge base

The Delta Programme Signal Group - The Delta Programme is all about adaptive delta management: responding flexibly to changing circumstances and implementing appropriate measures in good time. The *Delta Programme Signal Group* monitors changes in the climate, sea level, hydrology and land use with indicators that relate to both the past and the future. This makes it clear when changes may be required to the course or pace of the Delta Programme. In the past, the signal group triggered more research (Haasnoot et al., 2020). An overview of monitoring series for those indicators can be found in the 'Signal Portal'. The Signal Group consists of substantive experts from authoritative knowledge institutes that are relevant for the Delta Programme (Haasnoot, Van 't Klooster and Van Alphen, 2018). Currently, these are: the Royal Netherlands Meteorological Institute (KNMI); the Netherlands Environmental Assessment Agency (PBL); the Social and Cultural Planning Office (SCP); Deltares; Wageningen University & Research (WUR); Rijkswaterstaat – Water, Transport & Living Environment (RWS-WVL); Statistics Netherlands (CBS).

The recommendations of the Signal Group are included in the annual Delta Programme. According to the IPCC report published in August 2021, increasingly more signs indicate that the sea level may rise at a pace faster than assumed in the Delta Scenarios. In 2018, Deltares explored, in anticipation of the IPCC report, how this could impact the **Delta Programme**. Subsequently, in 2019, the Minister of Infrastructure and Water Management and the Delta Programme Commissioner jointly initiated **the Sea Level Rise Knowledge Programme** (see Section 4.3.2). The aim has been to assess strategies beyond 1m sea level rise. Current plan of 2015 focuses on up to 1 m of SLR in 2100. The knowledge program on SLR was installed after studies from Deltares and KNMI and a signal from the signal group.

Delta Facts - these are online knowledge dossiers containing a brief summary of what is known about a particular topic. Water managers can use this information during decision-making. Deltafacts were

¹³⁴ The Delta Congress on November 9, 2023.

¹³⁵ <https://www.klimaateffectatlas.nl/en/> (accessed 20.12.2023).

¹³⁶ See further: <https://www.klimaateffectatlas.nl/en/how-to-use> (accessed 20.12.2023).

developed as part of the Deltaproof programme of the Foundation for Applied Water Research (STOWA) and the joint water authorities.

Knowledge conferences - a knowledge conference has taken place every year since 2011. Since 2015, the National Water and Climate Knowledge and Innovation Programme has been responsible for organising the conferences. Now the Delta Programme organises the Delta Congress yearly in November, as well as knowledge conferences for the three Delta Themes and network conferences for regional delta programmes. At the Delta Congress, the Delta Plan for the next year is presented.

Delta Programme Knowledge Network - this network consists of representatives of the themes and areas covered by the Delta Programme and representatives of knowledge institutes. It discusses the knowledge required, the knowledge offered and ways to access it. The knowledge institutes involved include Deltares, the Environmental Research Agency (PBL), the Royal Netherlands Meteorological Institute (KNMI), STOWA, Delft University of Technology and Wageningen University and Research.

Knowledge agenda - innovations and answers to knowledge questions are needed for the optimal implementation of the Delta Programme. Those knowledge questions, which emerge from the themes and areas of the Delta Programme, are brought together in the knowledge agenda. The agenda includes application-oriented knowledge, innovations (technical and otherwise) and in-depth research. Once every two years, the agenda is updated and included as a background document accompanying the Delta Programme.

The new Delta Climate Center

A new Delta Climate Center has been established in Vlissingen. The Center will work on education and research on water and energy management and new forms of food supply. There will be a continuous learning path for students as well as new courses at knowledge institutions in Zeeland. The research focuses on the themes of water, energy, food and bio-raw materials. Delta Climate Center also stimulates business development and startups involved in water, food and energy. The Zeeland delta is the living lab of Delta Climate Center. Here, several parties are working on solutions for climate and sustainability issues in deltas. The Center is the result of a cooperation between government, knowledge institutes and private sector.¹³⁷

A national climate adaptation portal

In recent years, several tools for spatial adaptation have been developed and fine-tuned under the Delta Plan on Spatial Adaptation¹³⁸, including the [Climate Impact Atlas](#), [Stress test](#), [Climate-proof City Toolbox](#), [Climate Damage Atlas](#) and the [Risk Dialogue Roadmap](#).¹³⁹

Other activities/initiatives

- Water safety portal ([Waterveiligheidsportaal](#), WVP) supports information exchange between inspection, policy, planning and management of dikes.
- National information system water and flooding ([Landelijk Informatiesysteem Water en Overstromingen](#), National information system water and flooding ([Landelijk Informatiesysteem Water en Overstromingen](#), LIWO) contains all professional open data and maps.

¹³⁷ For more information, see [Welkom bij Delta Climate Center | Delta Climate Center](#) (accessed 20.12.2023).

¹³⁸ <https://klimaatadaptatienederland.nl/en/> (accessed 20.12.2023).

¹³⁹ Ibid.

4.4 Financial Programs and Tools Related to Sea Level Changes

This section provides insight into how adaptation measures related to sea level changes are financed, as well as information about the financing of the National Water Program. Various sources of financing for the water tasks are relevant, including the **Delta Fund**, which provides resources for water safety and freshwater supplies, water quality and water management. In addition, there is money for the financing of the national waterways through the Infrastructure Fund, which will be replaced by the **Mobility Fund**. The financial frameworks and priority agreements are also described.¹⁴⁰

In 2022, the total costs of water management (in a broad understanding) amounted to 8.2 billion euros. The distribution of the total costs is 44 percent for water boards, 22 percent for municipalities, 17 percent for drinking water companies, 15 percent for the government and 2 percent for provinces. All households and companies in the Netherlands contribute to the costs of water management through various taxes and the drinking water bill. Between 2018 and 2022, the amount for households in an owner-occupied home increased by approximately 2 percent. Households in rented accommodation have started paying approximately 1 percent more.¹⁴¹

4.4.1 Funding adaptation measures through taxes and the collective solidarity principle

In the Netherlands, funding for protection against sea level changes comes from both **local and national taxes**.¹⁴² This system is based on **the solidarity principle**, meaning everyone shares the responsibility to keep the country safe from the risks of sea level changes. Much of the Netherlands' economic activity happens in areas that could be affected by flooding from the sea, so protecting these areas is important for everyone in the country as the vulnerability is relevant for everyone in the country. As a result, everyone contributes through taxes to ensure the nation is safeguarded against sea level changes (Van Rijswijk and Salet, 2012). Solidarity thus implies that the risks and burdens that group members face should be shared by the group as a whole, that is, all inhabitants of the Netherlands (Dawson and Verweij, 2012). As such, it implies a (re)allocation of individual flood risk burdens to the collective which is institutionalised into the flood risk management approaches.

Funding for water management and flood defence is a collaborative effort between different government levels. **On the national level**, everything that falls within the Ministry of Infrastructure and Water Management's responsibility is 100 percent financed by the ministry, i.e. the national government. Everything that has to be reinforced, such as flood defences, are handled through **the National Flood Protection Program** and the regional water authorities. Such measures are paid **50-50 by the regional water authorities and the national level government**.

Local water infrastructure and flood defences fall under the financial responsibility of regional water authorities, such as the water boards. These authorities are partly funded by local taxes, which help cover expenses for household water treatment and flood defences. Regarding project financing, regional water authorities collectively contribute 40 percent of the costs. The one initiating the project, typically also a regional water authority, is responsible for the remaining 10 percent. The funding process is centralized,

¹⁴⁰ <https://open.overheid.nl/repository/ronl-0c5086b3029ab6a4ab28d52838ce44d5e6285d1a/1/pdf/bijlage-nationaal-water-programma-2022-2027.pdf> p.295 (accessed 20.12.2023).

¹⁴¹ Ibid.

¹⁴² Information from informant, November 2023.

and the regional water authorities submit their 40 percent contributions into a central government fund, which is then combined with the 50 percent share from the national government. So, this central fund accumulates 90 percent of the total project cost, which is distributed as needed. In summary, **the national government initially contributes 50 percent, regional water authorities collectively add 40 percent, and the project initiator covers the final 10 percent.** (see Figure 14).

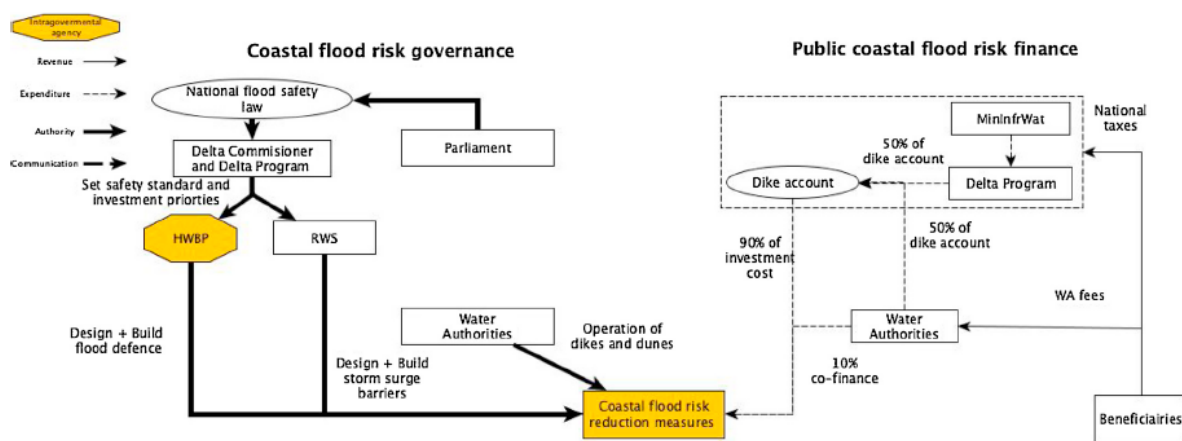


Figure 14. The financing of coastal flood risk governance in the Netherlands. Source: Bisaro et al. 2020.

4.4.2 Delta Fund and Infrastructure Fund/Mobility Fund

Once a year, the Dutch government publishes the Delta Fund and the Mobility Fund as parts of the budget of the Ministry of Infrastructure and Water Management. The budget shows the expected expenditure for existing and new plans. The budgets allocated to the main water system are allocated from the Delta Fund; those for the main waterway network from the Mobility Fund. The concrete projects are included and explained in the project overview of the Multi-year Infrastructure, Space and Transport Program (MIRT). This MIRT Overview is also published annually on Budget Day.

The reason that the Delta Fund exists is that it can better implement the specific objectives of this the Delta Programme, as stipulated in the Water Act. Within the Delta Fund and the Mobility Fund, annual balances (more or less expenditure in any year) may be transferred to subsequent years - in contrast to the ministry's policy budget of Infrastructure and Water Management. In this way, (cash-related) delays and accelerations of projects do not have to lead to budgetary bottlenecks.

The Delta Program contains measures that are fully or partially financed from the Delta Fund, as well as measures in the field of water safety and freshwater for which the government bears (partial) responsibility. In addition, the Delta Program includes measures for which the government is not responsible, such as those for the regional water system and combating flooding.

4.4.3 Financing for acceleration of spatial adaptation

Based on that extreme weather events are becoming increasingly common; the Delta Plan for Spatial Adaptation sets out the ambition to accelerate and intensify the approach to spatial adaptation. The Delta Plan for Spatial Adaptation describes all the projects and measures for making the Netherlands water-

robust and climate-resilient by 2050.¹⁴³ To enable acceleration, the government aims at decentralization. Temporary resources are made available in the form of **subsidies from the Delta Fund**. In this way, the government aim to give impetus to the implementation of measures at a **regional level** combating flooding. The Water Act has been amended for this purpose. The law requires the Minister of Infrastructure and Water Management to evaluate the effectiveness of the subsidies within 5 years.

To incentivise spatial climate adaptation measures, municipalities can apply for a fund to cover half of their expenses related to such measures.¹⁴⁴

Until 2050, the Delta Fund is expected to have EUR 27.4 billion available for the Delta Programme, while EUR 30.8 billion is needed.¹⁴⁵ In the period 2024-2037, approximately EUR 25 billion will be available in the Delta Fund, bringing the average annual budget to almost EUR 1.8 billion. Some of these resources are available for projects that are part of the Delta Program, but not all of them. The Delta Fund also covers government expenditure that falls outside the Delta Program, such as the costs for management and maintenance of the main water system, and network-related costs and other expenses. Of the approximately EUR 1.88 billion available annually in the Delta Fund in the period 2038-2050, approximately EUR 1.14 billion per year has been earmarked for management, maintenance and replacement and network-related and other expenditure. This means that an **investment budget** of approximately EUR 0.73 billion per year is available for the Delta Program in the period 2038-2050. **This concerns the budget for the available or earmarked series for new flood protection measures, freshwater and the reservations relevant to the Delta.**¹⁴⁶

4.5 Success Stories and Challenges related to Sea level Governance

A relevant assessment took place in 2022 on behalf of the Ministry of Infrastructure and Water Management as part of the Sea Level Rise Knowledge Programme. The assessment, conducted by Sweco, explored **the role of sea level rise in the decision-making processes at the regional level** in three pilot areas in the Netherlands (Swinkels and Raadgever, 2022).

The three pilot areas differ in geographic location, and type of problem related to sea level rise:

- The North Holland Region is located in the north-western part of the Netherlands where bulb cultivation and salinization come together, especially in the Koegraspolder. An example project in the field of water safety in Den Helder is the result of an unbreakable dike with houses on it in the Dijkenkwartier.
- The Zwolle region is a leader in the field of spatial planning adaptation, and the areas around it confirm to this. There is a major housing construction challenge in the region and the area also has an ‘NOVI-status¹⁴⁷’, which focuses on developing a climate robust and economically vital

¹⁴³ <https://english.deltaprogramma.nl/three-topics/spatial-adaptation/delta-plan> (accessed 20.12.2023).

¹⁴⁴ [Impulsregeling klimaatadaptatie - Klimaatadaptatie \(klimaatadaptatienederland.nl\)](https://impulsregeling.klimaatadaptatie.nl/) (accessed 20.12.2023).

¹⁴⁵ Deltaprogramme 2024, chapter 7 ‘Deltafonds’. Available in Dutch at [Deltaprogramma 2024 | Deltafonds](https://deltaprogramma.nl/deltafonds) (accessed 20.12.2023)

¹⁴⁶ Ibid.

¹⁴⁷ NOVI stands for National Strategy on Spatial Planning and the Environment (Nationale Omgevingsvisie - NOVI) and provides a sustainable perspective for our living environment (which comprises both the built and the natural environment). See further [English, French and German version | De Nationale Omgevingsvisie](https://english.nationaleomgevingsvisie.nl/). (accessed 20.12.2023).

region with a permanently attractive living environment. Zwolle is already busy exploring the effects of sea level rise and includes the surrounding region.

- In the Zeeland region, the focus was on the municipality Vlissingen which is located on the Western Scheldt and is directly connected with the open sea. As such, it will be directly affected by sea level rise. Vlissingen faces a large task in handling the interface between water safety and spatial planning as the city is located in front of, on, and directly behind the primary barrier.

The Sweco-report provides an initial picture of the extent to which, and the manner in which, effects of sea level rise has been integrated in the administrative agenda of actors involved in regional and local spatial developments. It gives insight into considerations, networks, decision-making and assessment processes, success factors and dilemmas.¹⁴⁸ The report, based on the assessment and the interviews with regional and local decision-makers, **identified various dilemmas and challenges**. We mention several of them below:

1. Lack of translation into regional effects and goals

The regional pilot areas **struggled with the translation of strategic visions into concrete (policy) goals and actions. Uncertainty about the magnitude of regional effects** made it difficult to take concrete measures and to communicate about this with individual stakeholders. The government want sea level rise to be included in spatial decision-making and spatial choices that are now being made, but it was found that regional and local actors do not yet have sufficient knowledge to do so. This was attributed to that regions do not have sufficient resources to be aware of the available knowledge within the sea level rise knowledge program or because the required knowledge is still being developed. Thus, sea level rise is still an abstract theme in many regions. Concreteness of the problems surrounding sea level rise remain absent due to a **lack of translation into regional effects and absence of clear goals**. The lack of clear objectives from the government was seen as an obstacle towards an action-oriented approach by regional actors. The Sweco-report explains that there is a need for a framework for adaptation, for example a sea level rise ‘stress test’. In this way, scenarios for sea level rise and the main solutions at national level could be translated into regional effects and based on these specific regional goals could then be designed.

2. Lack of a sense of urgency

The sense of urgency differs per municipality and region and this difference can form an obstacle in cooperation between regional areas. The regions emphasized that **a sense of urgency is necessary to foster an action-oriented approach** to deal with sea level rise in spatial decision-making. The Sweco-report found that a clear success factor is that actors recognize a high sense of urgency. In the pilot areas where the urgency was high, there was often a **sense of ownership** amongst the actors. In many cases this feeling was driven by a personal drive or ambition that arose from a sense of responsibility towards future generations and a strong interest in water and climate related problems.

3. Short- and long-term interests

The discourse surrounding sea level rise is to a certain extent determined by its ability to include long-term interests in current decision-making. The Sweco-report found that there are many spatial challenges in all regions in which mutual prioritization must be made. Assignments such as housing construction and energy transition take place in the shorter term and are therefore higher on the agenda than actions surrounding sea level rise. In addition, local administrators indicated that it is difficult to make

¹⁴⁸ The assessment was carried out on behalf of the Ministry of Infrastructure and Water Management, in the context of Track V of the Sea Level Rise Knowledge Programme. This track focuses on the implementation strategy, investigating what is needed to involve all relevant parties the Knowledge Program and how a change in governance can affect implementation.

administrative decisions at a time when the consequences are not yet directly experienced. So, the long-term nature of the challenges surrounding sea level rise clashes with the current, relatively short-term policy horizon of regional governments.

4. Sectoral and administrative boundaries

The current administrative and sectoral boundaries represented obstacles to cooperation. In the various regions, the Sweco-study found that it appears that actors tend to focus primarily on the regulatory or policy framework applicable within one's own administrative sector or borders. A major obstacle identified was **the lack of cooperation between different sectors** due to the difference in language and way of thinking, for example between spatial planning and water management. These challenges were also attributed to that spatial planning is often fragmented within different portfolios and sectors. Transcending sectoral boundaries must happen at every level of government. The report found that the lack of intersectoral cooperation at the national level is perceived as an obstacle. Also, in terms of content, some subjects did not fall within the mandates of regional and/or local governments. For example, on the topic of salinization it has been difficult to involve the municipalities. Currently, there was mainly cooperation between the water board, the province and the national government, but it was said that it is necessary to involve municipalities and to look beyond sectoral boundaries. The Sweco-report highlights that during all their interviews, the importance of an **integrated problem approach** was emphasized. In the face of the large accumulation of tasks, i.e. the need to tackle several challenges simultaneously within the geographical area of responsibility, and limited space in the regions, integrated approaches are necessary.

5. Distribution of responsibilities

Even though the Netherlands has a quite centralised approach to dealing with sea level changes, the responsibilities for dealing with climate change and sea level rise are not centralized within one actor, but distributed across the province, water board, municipality and government. The Sweco-report found evidence of collaboration through national or regional programs in all regions. However, the report also found that **the financial task remains difficult: who takes the responsibility and which actor pays**. In some areas, actors experienced ambiguity regarding responsibilities, for example between Rijkswaterstaat and the water board in the water safety task. It was mentioned several times by their informants that more guidance is needed from the national government and that an assessment framework could be provided by the government. The regions expressed that they need more support to make political steps and choices, and local administrators should be more directly involved in the development of assessment frameworks. The Sweco-report highlights that it is important that the government understands the different perceptions and dynamics that might play at the local levels. For example, the government does not sufficiently take into account that, at the local level, there is a great dependence on private stakeholders (farmers, companies) for the achievement of spatial planning related ambitions.

6. Communication and collaboration with local and regional stakeholders

The Sweco-report found that the sense of urgency among other stakeholders, for example farmers and residents, was low in many regions. This is especially true in the North Holland region, an area prone to the production of flower bulbs. The problem surrounding salinization is taking place on plot/area-use level, so part of the solution must therefore come from the farmers. According to the report, the agricultural sector is not yet sufficiently aware of the consequences of sea level rise, the need for measures and that they themselves too must take measures to adapt to sea level rise. The Sweco-report highlights that the effects of sea level rise on spatial planning remain elusive for many stakeholders, the **governments must better communicate the problem of sea level rise to residents and companies**. This

includes that it is the role of governments to outline future scenarios and provide knowledge about the scale of the problem, and to create a sense of urgency among residents and businesses.

7. Regulatory barriers

An obstacle to the making of legal agreements for adaptation to sea level rise is that the extent and speed of sea level rise in the long-term is partly an open knowledge question and partly fundamentally uncertain. This also brings uncertainty how to deal with this in the main water framework and spatial planning. The Sweco-study recognized this tension in the various interviews, as well as at the same time, there is a need for **no-regret agreements** about sea level rise now to be included in spatial development. An obstacle that was found in the current ambitions and visions at provincial, regional and water board level is that administrative aspects are constrained by boundaries and mandates. Several regions emphasized that no actor within the current administrative boundaries can tackle the problem of sea level rise alone and that a joint approach is needed that is supported by policy. Furthermore, a need for shared visions looking over work areas was mentioned and that applicable laws should not hinder the combination of different tasks.¹⁴⁹ Some of their informants also commented that too many rules apply, and that decisions must be made based on proper consultation and consultation expertise, to ensure flexibility. Too many rules can lead to hindering the adaptability of solutions.

The non-binding nature of the 'water test' was also seen as an obstacle considering the current legislation and regulations. The 'water test' is an instrument that explicitly takes water management interests into account, and in a balanced manner, when drawing up spatial plans and decisions. It brings the initiator of a spatial plan and the water manager into dialogue at the earliest possible stage. According to the findings of the Sweco-report, however, the water test is often applied too late in the planning process. A revision of the 'water test' is needed to include sea level rise as a mandatory element in spatial planning. Long-term effects must be considered, and the instrument must be more enforceable.

Recommendations

The Sweco-report advises to use tracks 4 and 5 of **the Sea Level Rise Knowledge Program**¹⁵⁰ to pay attention to the **interaction between available knowledge and formulating an action perspective** for the regions. Uncertainty about the magnitude of regional effects has made it difficult for the regions to take action. This points to the importance of having **no regrets when formulating measures**, even though not all knowledge is yet available. The report's authors (Swinkels and Raadgever, 2022), recommend the '*wanting, knowing and working*' methodology as a framework to identify recommendations in the areas of knowledge, policy and implementation. This methodology describes a continuous learning process, where iterative opportunities and vulnerabilities are mapped (knowledge), ambitions, goals and strategies are formulated (want) and their implementation becomes secured in policy, regulations and implementation agendas (works).

The Sea Level Rise Knowledge Program identifies opportunities and vulnerabilities. It is recommended to start with actions as soon as possible based on already generated knowledge. No regret measures are to be formulated and implemented. The first iteration from 'knowing' to 'wanting' and 'working' can take place during the term of the knowledge program (2019-2026). This iteration focuses on short-term actions and keeping long-term solutions open. Lessons can be learned for subsequent wider application.

¹⁴⁹ An example is that the Natura 2000 legislation conflicts with the water safety task.

¹⁵⁰ Track 4: Alternatives and adaptation pathways: what is the action perspective for the distant future? Track 5: Implementation strategy; which communications, changes in behaviour and transitions are needed, and possible, to prepare for this in good time?

After completion of the sea level rise knowledge program in 2026, there will be many changes and more knowledge has been developed that can be applied in (spatial) decision-making about how to deal with sea level rise. If all goes well, there is enough knowledge to further sharpen 'wanting' and 'working' and to apply it broadly to fit. Given the fundamental uncertainty, the cycle of knowing, wanting and working must then be completed continuously.

Other key recommendations from the authors of the Sweco-report are:

- Working towards clear objectives from the government
- Information provision and communication about regional effects of sea level rise
- Focus on informing and raising awareness of local administrators and the civil service
- Utilizing area knowledge, facilitating knowledge sharing various governments and stakeholders
- Focus on integrated knowledge development, bridging the gap water and spatial domain
- To transcend sectoral boundaries, also from the knowledge program Sea level rise
- Focus on network formation
- Building a future perspective
- Facilitate an experiment in collaboration and sharing responsibilities
- Further preparation of the water test and Stress Test-Sea Level Rise
- Commit to long-term integration in legislation and regulations

5 Governance of Sea Level Changes in the United Kingdom

The United Kingdom (UK) consists of a group of islands off the western coast of Europe and is made up of England, Scotland, Wales and Northern Ireland. It is surrounded by the Atlantic Ocean, the North Sea, the English Channel and the Irish Sea. The UK's geography is characterized by rugged hills and low mountains. England consists mostly of lowland terrain and upland or mountainous terrain in the Northwest. Scotland and Wales are the most mountainous, covered in mountain ridges separated by deep valleys. The UK has about 12,400 km of coastline, ranging from tall cliffs to beaches and marshes. The capital city, London, is situated on the tidal River Thames in the Southeast of England.

Sea level rise and resulting impacts are already causing significant problems in the UK and are identified as a risk from climate change. Changes in sea level have significant implications for the UK, including coastal erosion and flooding, and require strong coastal management that builds resilience. Modelling studies have indicated that mean sea level rise contributes about five times more to projected changes in UK sea level extremes over the 21st century than any other contributing factor (i.e. storm surge activity, waves, tidal amplitudes) (Howard et al., 2019a).

The latest **UK Climate Change Risk Assessment (CCRA3)**¹⁵¹ highlights the risks related to sea level rise, including effects of flooding and erosion on communities and infrastructure, slope and embankment failures, and effects on saltwater intrusion, aquifers and agricultural lands. The assessment puts nearly all associated risks in the top urgency categories, needing stronger action or significant further investigation (Betts and Brown, 2021). The number of homes at risk from coastal flooding in England is expected to increase in the coming decades (Committee on Climate Change, 2018). According to the Environment Agency, choices will have to be made which coastal communities in England can be protected from the sea and which communities will have to be moved (Environment Agency, 2020). In Wales, around 40 coastal areas may need to relocate property due to risks from the sea (Welsh Government, 2020).

Governmental powers in the UK are divided between the UK Government, who retain some powers across the whole of the UK, and the three devolved administrations of Wales, Scotland and Northern Ireland. In this report, **we focus mainly on governance arrangements, knowledge base and funding mechanisms for sea level changes in England and the whole UK (where applicable)**. Where information about Wales, Scotland or Northern Ireland has been identified that may add additional or alternative perspectives, these have been included as case study examples.

5.1 Climate Change Adaptation in the UK

In the UK, the **Climate Change Act 2008**¹⁵² (for England, Northern Ireland and Wales) and **Climate Change (Scotland) Act 2009**¹⁵³ (for Scotland) set out the legal framework for addressing climate change mitigation and adaptation. The government is required to regularly assess the risks to the UK of the current and predicted impact of climate change and to set up climate change adaptation objectives and

¹⁵¹ <https://www.ukclimaterisk.org/> (accessed 10.01.2024)

¹⁵² <https://www.legislation.gov.uk/ukpga/2008/27/contents> (accessed 10.01.2024)

¹⁵³ <https://www.legislation.gov.uk/asp/2009/12/contents> (accessed 10.01.2024)

policy responses to the identified risks.¹⁵⁴ Responses to rising sea levels, coastal flooding and erosion, storms and high waves are part of the UK's approach to climate change adaptation. The Climate Change Act 2008 established clear statutory obligations for the UK Government to take action on climate change.

Under the Climate Change Act 2008, the UK Government must publish a **Climate Change Risk Assessment (CCRA)** every five years. The CCRA is used to determine the main government priorities for climate change adaptation which are described in the **National Adaptation Programme**. A new National Adaptation Programme is established every five years following the CCRA.

The Climate Change Act 2008 also set up the **Climate Change Committee**¹⁵⁵ as an independent, statutory body. The Committee has a legal duty to provide statutory advice to the UK Government and devolved administrations on emissions targets and the priorities for national adaptation plans and action, based on the CCRA Technical Report (Betts and Brown, 2021). The Committee has a duty to assess and report to Parliament on progress on emission reductions and climate change adaptation in England and Scotland.

The **third Climate Change Risk Independent Assessment (CCRA3)**¹⁵⁶ was published in 2021. The Technical Report assessed 61 risks related to climate change for the UK. The report also assessed the extent to which current UK adaptation plans will manage these risks. **The CCRA3 considered risk and adaptation for specific time periods (up to 2050 and up to 2080) under two climate scenarios (pathways to 2°C and 4°C global warming by 2100)**. These two scenarios were considered to broadly represent lower and upper rates of climate change consistent with current policies and policy ambitions for greenhouse gas emissions (Betts and Brown, 2021).

With the National Adaptation Programme (NAP), the UK government responds to the risks identified by the CCRA. The **third National Adaptation Programme (NAP3)**¹⁵⁷ sets out the actions that the UK government and others will take to adapt to the impacts of climate change in England for **2023 to 2028**. As climate change adaptation is a devolved matter, Northern Ireland, Scotland and Wales produce their own adaptation plans (see brief description in the box below).

Northern Ireland: In addition to the Climate Change Act 2008, the Climate Change Act (Northern Ireland) 2022 sets out requirements for climate change action plans. The Act also establishes a duty on the Climate Change Committee to undertake a mid-term assessment of progress and provide recommendations for Northern Ireland's Climate Change Adaptation Programmes. The second Northern Ireland Climate Change Adaptation Programme (NICCAP2) was published in 2019. The next NICCAP2 is due in 2024, responding to the CCRA3. Northern Ireland puts a strong emphasis on engagement with local authorities. The Department for Environment, Food and Rural Affairs supports this by funding the Climate Northern Ireland Project. The project has established a Local Government Climate Action Network that brings together ten of the 11 councils in Northern Ireland.

Wales: The current national adaptation plan for Wales was published in 2019. The next plan is due in 2024, responding to the CCRA3. Adaptation planning in Wales is supported by the Wellbeing of Future Generations Act 2015 and the Environment (Wales) Act 2016, which includes provisions for flood and coastal erosion management. The Welsh Government is committed to integrating the response to climate

¹⁵⁴ <https://www.gov.uk/guidance/climate-change> (accessed 10.01.2024)

¹⁵⁵ <https://www.theccc.org.uk/> (accessed 10.01.2024)

¹⁵⁶ <https://www.ukclimaterisk.org/> (accessed 10.01.2024)

¹⁵⁷ <https://www.gov.uk/government/publications/third-national-adaptation-programme-nap3> (accessed 10.01.2024)

emergencies across all government actions. The government is currently developing a five-year Strategy for Public Engagement and Action on Climate Change.

Scotland: The Climate Change (Scotland) Act 2009 requires the preparation of strategic programmes for climate change adaptation every five years, in response to the CCRA. The second Scottish Climate Change Adaptation Programme (SCCAP2) was published in 2019 and runs to 2024.

5.2 Governance Arrangements for Managing Sea Level changes

The **CCRA3** assessed eight risks related to 1) sea level rise, 2) coastal flooding and erosion, and 3) storms and high waves. Different urgency scores were assigned to these risks for England, Northern Ireland, Scotland and Wales. For five of the risks the CCRA3 found that more action was needed. The identified risks included:

1. Risks to and opportunities for agricultural and forestry productivity from extreme events and changing climatic conditions (including flooding, coastal erosion and saline intrusion) → **more action needed**
2. Risks to aquifers and agricultural land from sea level rise and saltwater intrusion → further investigation/watching brief
3. Risks and opportunities to coastal species and habitats due to coastal flooding, erosion and climate factors → **more action needed**
4. Risks to infrastructure services from coastal flooding and erosion → further investigation
5. Risks to offshore infrastructure from storms and high waves → sustain current action
6. Risks to people, communities and buildings from flooding → **more action needed**
7. Risks to the viability of coastal communities from sea level rise → **more action needed**/further investigation
8. Risks to businesses and infrastructure from coastal change → **more action needed**

One of the main identified risks is viability of coastal communities due to sea level rise. The CCRA3 summary for England concluded that there is “[l]ittle evidence of a strategic approach to identify and support communities at risk” (Sustainability West Midlands, 2021, p. 96).

In the UK, the focus of governance arrangements for sea level changes is on i) management of flooding and coastal erosion and ii) on local planning. Under the **NAP3**, UK government actions related to sea level rise, coastal flooding and erosion include:

- Supporting the creation, restoration and enhancement of estuarine, coastal and marine habitats.
- Investment in flood and coastal erosion schemes.
- Review of the National Planning Policy Framework, including for areas at the coast in managing and adapting to coastal change and sea level rise.
- Updating Shoreline Management Plans.
- Delivering the National Flood and Coastal Erosion Risk Management Strategy Roadmap (FCERM) to 2026.
- Improving the National Coastal Erosion Map and flood forecasting capabilities in higher-risk areas.
- Making sustainable drainage systems mandatory in new developments.
- Working with water companies to mitigate the risk to water supply from sea level rise and saltwater intrusion.

5.2.1 Actors, roles and responsibilities in sea level governance (at various governance levels)

The UK government identifies key **risk management authorities** for England and defines their roles and responsibilities in relation to flood and coastal risk management.¹⁵⁸ At the national level, the **Department for Environment, Food & Rural Affairs (Defra)** is responsible for **providing policy** on flood and coastal erosion risk management in England. This includes coastal flooding and erosion related to sea level rise. Defra provides **funding for flood risk management** in England through grants to the Environment Agency, local authorities and internal drainage boards. Defra also works closely with the devolved administrations in Scotland, Wales and Northern Ireland to ensure coherent adaptation to climate change across the UK.

The **Environment Agency** is the strategic risk management authority at national level for England. It provides supervision and **statutory guidance to local authorities and planning authorities** in England on risk management, planning applications, local plans and environmental assessments regarding flood risk and coastal erosion. The Environment Agency prepares the **Flood and Coastal Erosion Risk Management Strategy for England (FERCM)**¹⁵⁹ and reports to the minister on flood and coastal erosion risk and how national and local strategies are being applied by all relevant authorities (UK Government, 2010). In the FCERM Strategy, the Environment Agency also determines the roles and responsibilities of risk management authorities in England (Environment Agency, 2020, Annex A). The Environment Agency further performs several key functions, including:

- Prepares **preliminary flood risk assessments** and **flood risk management plans** for flooding from main rivers, reservoirs and the sea under the Flood Risk Regulations 2009.
- Provides the **national coastal erosion risk map** and **flood risk maps** by river basin district.
- Operates **flood warning systems** and issues related **flood alerts and warnings**.
- Carries out work to manage flood risk from main rivers and the sea under the Water Resources Act 1991.
- Carries out works to manage coastal change under the Coast Protection Act 1949.
- Carries out surveys and mapping under the Flood Risk Regulations 2009 and Water Resources Act 1991 to inform flooding and coastal erosion risk management.
- Designates structures and features of the environment that affect flood or coastal erosion risk.
- Issues consent for works on or near structures protected by its bylaws, including flood and sea defences.

County councils and **unitary authorities** are the **lead local flood authorities** in England. They have operational responsibility for managing the risk of flooding from surface water and groundwater in their area. This includes local flood risk management strategies, preliminary flood risk assessments, flood hazard and risk maps and flood risk management plans. County councils are the upper tier of local government in many areas in England (see details about the tiers in the box below). Lead local flood authorities do not have responsibility for flooding from the sea. The exception are unitary authorities in coastal areas that function as coastal protection authorities.

¹⁵⁸ <https://www.gov.uk/government/collections/flood-and-coastal-erosion-risk-management-authorities#lead-local-flood-authorities> See also National Flood and Coastal Erosion Risk Management Strategy Annex A: https://assets.publishing.service.gov.uk/media/5f5f960dd3bf7f7231ac64be/15482_Environment_agency_digital_AnnexA_PDFa.pdf (accessed 10.01.2024)

¹⁵⁹ <https://www.gov.uk/government/publications/national-flood-and-coastal-erosion-risk-management-strategy-for-england--2> (accessed 10.01.2024)

District councils, borough and city councils are responsible for **managing flood risk from the sea** and ordinary watercourses. District councils, borough and city councils are the lower tier of local government in many areas in England. District councils and unitary authorities in coastal areas are **coastal protection authorities**. They are the lead authorities for **coastal erosion risk management** activities including operating and maintaining sea defences, carrying out coast protection work and taking flood risk into account in local planning and development decisions. District councils and coastal unitary authorities are also responsible for producing long-term **shoreline management plans**. Coastal protection authorities work closely with the Environment Agency on coastal risk erosion management activities. They also work with lead local flood authorities and other stakeholders to ensure that flood risk management is effectively incorporated in local development decisions.

Local government in England explained

In many parts of England, local government has two tiers: **1. county councils (upper tier) and 2. district councils, borough or city councils (lower tier)**. County councils are responsible for providing services across the county while district councils are responsible for smaller areas within a county. In other areas, local government consists of single tier councils, which can be unitary authorities, London boroughs or metropolitan boroughs. Unitary authorities combine the functions of county and district councils. The area for which unitary authorities are responsible vary from an entire county to parts of a county or a city.

Internal drainage boards are independent public bodies that work in partnership with other authorities to actively manage flood risk in low lying areas. This includes carrying out work to manage flood risk from the sea, in consultation with the Environment Agency.

There are **12 regional flood and coastal committees** in England. Their members are appointed by the Environment Agency and lead local flood authorities. The function of these committees is to connect flood risk management authorities and other relevant bodies within their regions to ensure coherent approaches and investment in flood and coastal erosion risk management across catchments and shorelines.

Other risk management authorities include **highway authorities, water and sewage companies** and the **Department for Levelling Up, Housing and Communities**. The latter is responsible for **local planning and building regulations**.

The **Local Government Association Coastal Special Interest Group**¹⁶⁰ (SIG) brings together 57 local authorities from around the coast of England. The SIG provides a forum for exchange, for liaison with other coastal interest groups and for raising awareness of the issues of coastal communities at the national government level. The SIG Coastal Adaptation Working Group is working with communities on climate change adaptation projects.

Private landowners also have a role in coastal protection. They are responsible for protecting their own property from flooding and erosion and must take action according to statutory planning regulations.

¹⁶⁰ <https://lgacoastalsig.com> (accessed 10.01.2024)

In Scotland the Scottish Government has overall responsibility. The **Scottish Environment Protection Agency (SEPA)**¹⁶¹ is the **strategic flood risk management authority** under the Flood Risk Management (Scotland) Act 2009. SEPA is not responsible for management of coastal erosion but has produced Flood Risk Management Strategies that do also consider coastal erosion.

Local authorities have a role in coast protection and Local Coastal Partnerships implement Integrated Coastal Zone Management. The Scottish Coastal Forum is a stakeholder group that works closely with the Scottish Government and advises Marine Scotland.

In Northern Ireland, flood and coastal erosion risk fall under the responsibility of the **Department of Agriculture, Environment and Rural Affairs (DAERA)** and the **Department for Infrastructure (DfI)** (Amey Consulting 2019). The **Office of Public Works** has overall responsibility for flood and coastal erosion risk management.

- DfI is responsible for flood defence, flood risk assessments, flood risk management plans and strategies; coastal defences that protect road and rail network; strategic planning and planning policy.
- Translink is responsible for maintaining sea defences relating to railway infrastructure.
- DAERA is responsible for marine planning, marine licensing, nature conservation and supporting local authorities and DfI.

Northern Ireland has seven local authorities with a coastline. The local authorities are responsible for local development planning and management and planning enforcement. They have a requirement to ensure that future plans and strategies reduce the risk from coastal change (e.g. no inappropriate development in vulnerable areas). They have to identify areas likely to be affected by coastal change and make provision for development and infrastructure in these areas.

In Wales the Welsh Government has overall responsibility for national policy. **Natural Resources Wales**¹⁶² is the **strategic flood risk management authority**. The Flood and Coastal Erosion Committee, established 2017 under the Environment (Wales) Act 2016, advises Welsh Ministers on flood and coastal erosion risk management and facilitates communication between the flood and coastal erosion risk management sector and Welsh Ministers.¹⁶³

5.2.2 Key policies, programs, and planning guidelines for sea level governance

Flood and coastal erosion risk management

The UK Government published its national **Flood and Coastal Erosion Risk Management Policy Statement**¹⁶⁴ in 2020. The policy statement sets out a long-term ambition for resilience to flood and coastal erosion risk as part of the government's commitment to address climate change. In the policy statement, **coastal flooding and erosion are recognised as impacts resulting from rising sea levels**.

¹⁶¹ <https://www.sepa.org.uk/environment/water/flooding/> (accessed 10.01.2024)

¹⁶² <https://naturalresources.wales/flooding/?lang=en> (accessed 10.01.2024)

¹⁶³ <https://www.gov.wales/flood-coastal-erosion-committee/what-we-do> (accessed 10.01.2024)

¹⁶⁴ <https://www.gov.uk/government/publications/flood-and-coastal-erosion-risk-management-policy-statement> (accessed 10.01.2024)

The government provides a framework of five policy areas to guide activities on flood and coastal erosion risk management:

- 1) Upgrading and expanding national flood defences and infrastructure.
- 2) Managing the flow of water more effectively.
- 3) Harnessing the power of nature to reduce flood and coastal erosion risk and achieve multiple benefits.
- 4) Better preparing communities.
- 5) Enabling more resilient places through a catchment-based approach.

The latest **Flood and Coastal Erosion Risk Management Strategy for England (FERCM)** was published by **the Environment Agency** alongside the policy statement in 2020 (Environment Agency, 2020). The strategy provides a framework for operational activities and decisions to deliver the government's policy priorities. It presents **a vision for resilience to flooding and coastal change for 2100** and sets out objectives and **practical measures for risk management authorities over the next 30 years**.

The strategy emphasizes that effective planning and adaptation to flooding and coastal change will require action from many different stakeholders, including the risk management authorities, individuals, communities, the third sector, businesses, farmers, land managers and infrastructure providers. In *Annex A* of the strategy, the Environment Agency **lists who is responsible for flood and coastal erosion risk management in England** (as described above).

The **Flood and Coastal Erosion Risk Management Roadmap to 2026**¹⁶⁵ describes how the objectives and measures of the strategy will be put into practice. After the FCERM was published in 2020, an initial 1-year action plan showing the immediate actions was published in May 2021. Thereafter the Environment Agency worked with partners to develop a longer-term view and roadmap towards 2026. The aim is that by completing the roadmap the country will be on track to implement the strategy's 2100 vision. The roadmap also supports the implementation of government investment programmes including the GBP 5.2 billion Flood and Coastal Erosion Risk Management Investment Programme and the GBP 200 million Flood and Coastal Resilience Innovation Fund.

Shoreline management plans are an important part of flood and coastal erosion risk management in England and Wales. Coastal protection authorities are responsible for developing shoreline management plans, though often the plans are produced by coastal groups. These coastal groups are partnerships of local councils, other relevant local authorities and stakeholders as well as the Environment Agency in England and Natural Resources Wales in Wales.¹⁶⁶ There are 20 shoreline management plans across England. Shoreline management plans are non-statutory plans that set out a long-term **strategic approach for flood and erosion risk management and coastal adaptation over a 100-year time horizon**. They divide the coast into policy units and identify the most sustainable approach to managing flood and coastal erosion risks in the **short-term (0 to 20 years), medium term (20 to 50 years) and long term (50 to 100 years)**.

¹⁶⁵ <https://www.gov.uk/government/publications/flood-and-coastal-erosion-risk-management-strategy-roadmap-to-2026> (accessed 10.01.2024)

¹⁶⁶ <https://www.gov.uk/government/publications/shoreline-management-plans-smpps/shoreline-management-plans-smpps;https://naturalresources.wales/flooding/managing-flood-risk/shoreline-management-plans/?lang=en> (accessed 10.01.2024)

Defra provides **guidance on how to prepare shoreline management plans**.¹⁶⁷ There are **four policy options** that can be applied:

- **Hold the line** by maintaining or improving existing coastal protection.
- **Advance the line** by extending coastal defences seaward.
- **Managed realignment**, allowing the shoreline to move backwards and forwards through a managed approach.
- **No active intervention**, no investment in coastal defences.

The Environment Agency, Natural Resources Wales and the Coastal Groups are currently working to **update the shoreline management plans to include consideration of the latest climate change projections and a range of future scenarios (Environment Agency, 2020)**.¹⁶⁸ In England, the Environment Agency is working on a new web-based tool to improve access and use of shoreline management plans, as well as updating the evidence base and technical guidance. The update of shoreline management plans in England was identified as an action for government in the NAP3 and is expected to be completed by the end of 2024. Natural Resources Wales published updated guidance in 2021 (Natural Resources Wales, 2021).

Flood risk management plans (under the Flood Risk Regulations 2009) include assessments and actions to manage current and future flood risk including from the sea. The first cycle of flood risk management plans was developed for the period of 2015 to 2021 by the Environment Agency, lead local flood authorities, water and sewage companies. The **second cycle of plans** sets out **specific actions for 2021 to 2027** and encourages authorities to start taking an **adaptive approach to strategic flood risk planning using the 2018 UK climate change projections**. The Environment Agency provides guidance on how to prepare flood risk management plans.¹⁶⁹

Other relevant local flood risk management strategies include:

- Catchment flood management plans
- Estuary management plans
- Harbour management plans
- River basin management plans

Planning

The **National Planning Policy Framework**¹⁷⁰ provides the government's planning policies for England and how these are to be applied in local planning. The policy framework was updated in 2023. Chapter 14 of the policy framework specifies how the planning system should address climate change, flooding and coastal change. Development should be directed away from areas at highest risk of flooding, both current and future. This includes flooding from the sea. Planning should be informed by a **strategic or site-specific flood risk assessment** and take a **sequential, risk-based approach**.¹⁷¹

Strategic flood risk assessments are carried out by local authorities to assess the risk of flooding from all sources now and in the future and taking into account climate change allowances (described below).

¹⁶⁷ <https://www.gov.uk/government/publications/shoreline-management-plans-guidance> (accessed 10.01.2024)

¹⁶⁸ <https://naturalresources.wales/flooding/managing-flood-risk/shoreline-management-plans/?lang=en> (accessed 10.01.2024)

¹⁶⁹ <https://www.gov.uk/guidance/flood-risk-management-plans-frmps-how-to-prepare-them> (accessed 10.01.2024)

¹⁷⁰ <https://www.gov.uk/government/publications/national-planning-policy-framework--2> (accessed 10.01.2024)

¹⁷¹ <https://www.gov.uk/guidance/flood-risk-and-coastal-change#the-sequential-approach-to-the-location-of-development> (accessed 10.01.2024)

Strategic flood risk assessments are used to inform the local plan, plan policies and planning decisions. In areas at risk of flooding, **site-specific flood risk assessments** are conducted by developers as part of the planning application.

The sequential approach to planning and decision making includes two tests. First, a **sequential test** is applied to direct development to areas with the lowest risk of flooding (see Figure 15). Where this is not possible, **an exception test** is used to determine whether the development would be safe for its lifetime and provide wider sustainability benefits. The exception test requires additional two conditions to be met: 1. the sustainability benefits to the community from the development have to outweigh the flood risk, and 2. the development will be safe for its lifetime, will not increase flood risk elsewhere and, where possible, will reduce flood risk overall. The exception test is only to be used in cases where no alternative locations with lower flood risk can be identified. **Where the sequential and exception tests are not met, new development should not be permitted.** When preparing plans, local planning authorities in England need to take into account advice from the Environment Agency and other relevant flood risk management authorities.

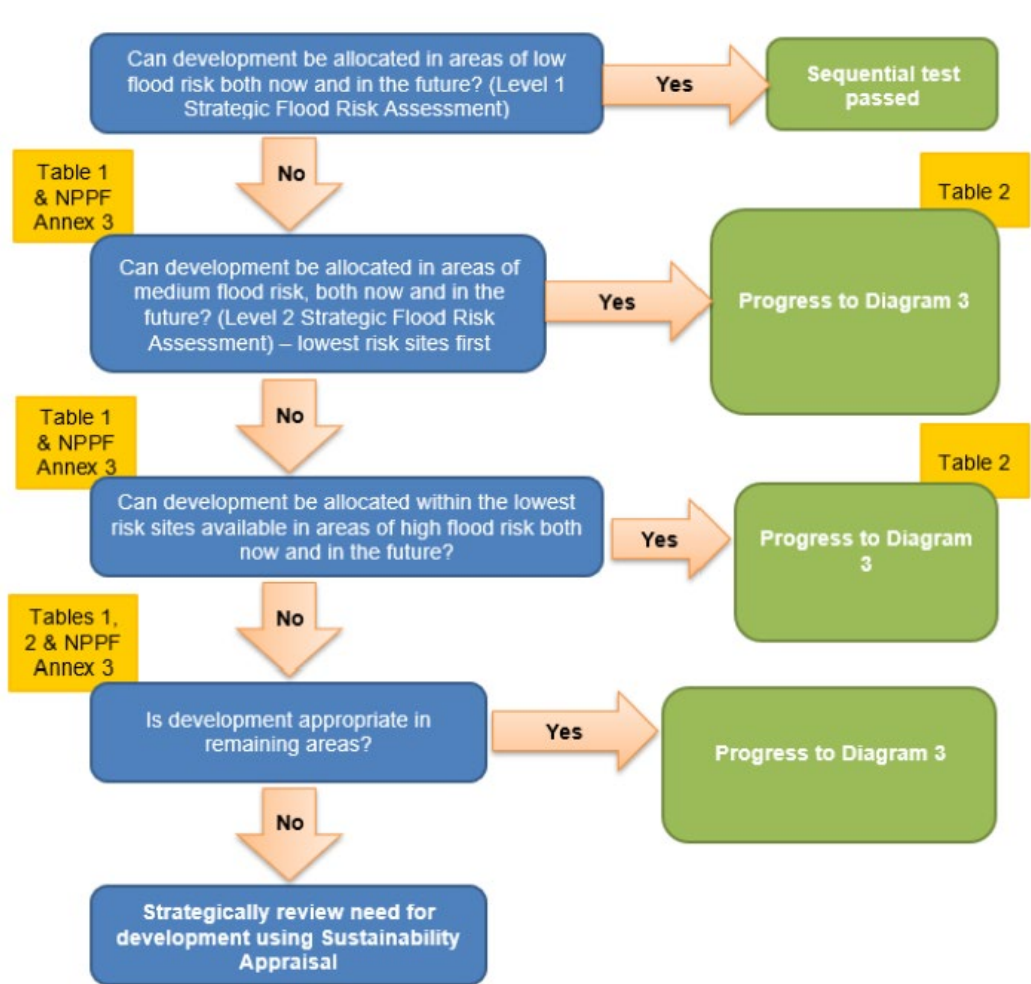


Figure 15. Application of the sequential test for plan preparation. Source: Gov.uk.¹⁷²

¹⁷² <https://www.gov.uk/guidance/flood-risk-and-coastal-change#the-sequential-approach-to-the-location-of-development> (accessed 04.01.2024)

In coastal areas, local authorities should ensure alignment of terrestrial and marine planning through integrated coastal zone management. Coastal planning should further avoid inappropriate development in areas vulnerable to coastal change. Areas that are likely to be affected by physical changes should be identified as **Coastal Change Management Areas**. In these areas, development should be subject to temporary permission and restoration conditions and only permitted under specified circumstances. Local authorities should further make provisions for the relocation of development and infrastructure away from Coastal Change Management Areas where needed.

Local authorities in coastal areas should take account of the **UK Marine Policy Statement** and **marine plans** in their planning policies and decisions.¹⁷³

Planning guidance: flood risk and coastal change

The national government provides guidance to local authorities and developers in England on how to account for and address risks associated with flooding and coastal change in planning processes.¹⁷⁴

The Environment Agency provides a **Flood Map for Planning** in England (<https://flood-map-for-planning.service.gov.uk/>) The preparation of Flood Hazard Maps and Flood Risk Maps is a specific requirement of the EU Floods Directive. However, the flood zones on this map do not consider the possible impacts of climate change, and **thus do not consider future sea level rise**.

Separate guidance is provided to local authorities and developers on how to integrate **climate change allowances** in flood risk assessments.¹⁷⁵ **Climate change allowances are predictions for anticipated change including for sea level rise, offshore wind speed and wave height**. The climate change allowances should be considered in all spatial planning processes and should be used by local planning authorities when preparing strategic flood risk assessments and by developers when preparing flood risk assessments for planning applications and development consent orders for nationally significant infrastructure projects.

Sea level rise

Sea level allowances are provided by river basin district for four epochs **up to 2125**, based on a baseline of 1981-2000 (see Figure 16). The allowances are based on percentiles¹⁷⁶ with the higher central allowance based on the 70th percentile and the upper end allowance based on the 95th percentile of the projections in the range. For flood risk assessments and strategic flood risk assessments, the guidance is to assess both the higher central and upper end allowances.

Storm surges

Storm surges are accounted for in the present-day extreme sea levels in Coastal Design Sea Levels – Coastal Flood Boundary Extreme Sea Levels (2018, last updated 2023).¹⁷⁷ Most of the Environment Agency coastal models apply these extreme sea levels. If a coastal model does not include storm surge

¹⁷³ <https://www.gov.uk/government/publications/uk-marine-policy-statement> (accessed 10.01.2024)

¹⁷⁴ <https://www.gov.uk/guidance/flood-risk-and-coastal-change> (accessed 10.01.2024)

¹⁷⁵ <https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances> (accessed 30.10.2023)

¹⁷⁶ A percentile describes the proportion of possible scenarios that fall below an allowance level. An allowance based on the 70th percentile is exceeded by 30% of the projections in the range. At the 95th percentile, it is exceeded by 5 % of the projections in the range. <https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#table-1> (accessed 30.10.2023)

¹⁷⁷ <https://www.data.gov.uk/dataset/73834283-7dc4-488a-9583-a920072d9a9d/coastal-design-sea-levels-coastal-flood-boundary-extreme-sea-levels-2018> (accessed 30.10.2023)

allowances, or when creating a new model, the guidance is to use the Coastal Design Sea Levels – Coastal Flood Boundary Extreme Sea Levels (2018) for extreme sea levels and to apply the climate change sea level rise values in the sea level allowances table (Figure 16).¹⁷⁸ Where assessment of a credible maximum scenario is appropriate, 2mm should be added for each year starting from 2017.

Offshore wind speed and wave height

Offshore wind speed and extreme wave height allowances are provided for two epochs between 2000 and 2125. These should be used where allowances are not already included in the Environment Agency’s coastal models.

Coastal erosion

The Environment Agency expects sea level rise to increase the rate of coastal erosion in England. The Environment Agency therefore advises to use **the coastal erosion risk maps** (see next section) to plan for any changes in the coastline, along with designated coastal change management areas and relevant policies in local plans.

Table 1: sea level allowances by river basin district for each epoch in mm for each year (based on a 1981 to 2000 baseline) – the total sea level rise for each epoch is in brackets

Area of England	Allowance	2000 to 2035 (mm)	2036 to 2065 (mm)	2066 to 2095 (mm)	2096 to 2125 (mm)	Cumulative rise 2000 to 2125 (metres)
Anglian	Higher central	5.8 (203)	8.7 (261)	11.6 (348)	13 (390)	1.20
Anglian	Upper end	7 (245)	11.3 (339)	15.8 (474)	18.1 (543)	1.60
South east	Higher central	5.7 (200)	8.7 (261)	11.6 (348)	13.1 (393)	1.20
South east	Upper end	6.9 (242)	11.3 (339)	15.8 (474)	18.2 (546)	1.60
South west	Higher central	5.8 (203)	8.8 (264)	11.7 (351)	13.1 (393)	1.21
South west	Upper end	7 (245)	11.4 (342)	16 (480)	18.4 (552)	1.62
Northumbria	Higher central	4.6 (161)	7.5 (225)	10.1 (303)	11.2 (336)	1.03
Northumbria	Upper end	5.8 (203)	10 (300)	14.3 (429)	16.5 (495)	1.43
Humber	Higher central	5.5 (193)	8.4 (252)	11.1 (333)	12.4 (372)	1.15
Humber	Upper end	6.7 (235)	11 (330)	15.3 (459)	17.6 (528)	1.55
North west	Higher central	4.5 (158)	7.3 (219)	10 (300)	11.2 (336)	1.01
North west	Upper end	5.7 (200)	9.9 (297)	14.2 (426)	16.3 (489)	1.41

Figure 16. Sea level allowances by river basin district. Source: Environment Agency.

In Northern Ireland, coastal erosion was not a major issue or management concern until recently. They applied the ‘Bateman Formula’ which assigns responsibility for securing assets along the coast to the government departments whose responsibilities most closely align with the asset at risk (Amey Consulting, 2019).

Sea level allowances in Scotland: Guidance issued by SEPA in May 2023 sets out allowances for sea level rise from 2017 to 2100 based on the UK climate projections 2018 (UKCP18) (SEPA, 2023). In addition, recognising that sea level rise will continue beyond the end of the 21st century, the guidance requires that **“an additional allowance of 0.15m per decade after the year 2100 be applied where the design life of a development is known to extend beyond that date”** (SEPA, 2023, p. 12). The allowance was derived from the 95th percentile estimate for RCP8.5, though it is left open to the planning authorities to use lower percentiles for the time beyond 2100 where this is deemed appropriate depending on the adaptability of the proposed development.

¹⁷⁸ <https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#table-1> (accessed 30.10.2023)

The Thames Estuary 2100 Plan

In 2012, the Environment Agency and their partners published **the first Thames Estuary 2100 Plan**¹⁷⁹. The Thames Estuary 2100 Plan is the leading adaptive pathways strategy in the UK. It is part of the Adaptation Pathway Programme which includes three further adaptive pathway projects in early phases.¹⁸⁰ The Thames Estuary 2100 Plan sets out a long-term strategy for managing tidal flood risk in the Thames Estuary to the end of this century and beyond. It defines **a series of possible management pathways**, each of which represents a different approach to mitigating increasing sea level rise and flood risk. The different flood defence options are monitored and reviewed every five and ten years to assess which option can provide protection for the most likely future scenario while also providing socio-economic and environmental benefits. The plan thus enables practitioners and policy makers **to adapt to flood risk over time** and implementing cost-effective, socio-economically and environmentally sustainable solutions. For example, if the projected rate of sea level rise increases, the deadlines for raising flood defences or implementing other flood risk interventions (e.g. active defences, flood plains) can be brought forward. Alternatively, if the rate of sea level rise decreases, flood risk interventions can be made later. Should projections increase significantly, pathways can be changed to an alternative option for managing the increasing flood risk. The Thames Estuary 2100 Plan is regularly reviewed and updated to incorporate new data, scientific evidence, and climate change projections.

The 10-Year Review of the Thames Estuary Plan 2100 in 2021 emphasized the continued need for an adaptive strategy due to climate change and sea level rise. The report noted that the sea level in the Thames Estuary has been rising, with accelerating rates in recent decades. The condition of flood defences was found to be largely satisfactory, with a focus on maintaining and upgrading where necessary. The number of people and properties in the Plan area was found to have increased, necessitating a review of flood risk management policies. The review report also covers wider findings that impact the implementation of the plan, including monitoring erosion and deposition, habitat changes, and the social, cultural, and commercial value of the area. These findings inform the strategy for habitat compensation and the assessment of wider benefits delivered by the Plan. The report highlights the importance of partnership and collaborative efforts among various stakeholders, including individuals, businesses, and government entities, to build resilience in the Thames Estuary. Such a collaborative approach is deemed crucial for making informed investment decisions and for supporting sustainable, resilient development in the face of sea level rise and climate change.

5.3 Knowledge Base and Tools for Sea Level Changes

5.3.1 UK Climate Projections 2018

The **UK Climate Projections 2018 (UKCP18)** update the UK Climate Projections 2009 (UKCP09).¹⁸¹ UKCP18 is prepared by the Met Office Hadley Centre Climate Programme and provides a set of climate projection and analysis tools to help decision makers assess climate risk. UKCP18 provides climate change projections up to 2100 globally (60km scale) and in the UK (12km and 2.2km scales). UKCP18 provides the official projections to inform government policy (for example the Flood and Coastal Erosion Risk Management Strategy and NAP3).

¹⁷⁹ <https://www.gov.uk/government/publications/thames-estuary-2100-te2100-monitoring-reviews/thames-estuary-2100-10-year-monitoring-review-2021> (accessed 11.01.2024)

¹⁸⁰ <https://engageenvironmentagency.uk.engageenthq.com/adaptation-pathway-programme> (accessed 11.01.2024)

¹⁸¹ <https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/about/what-is-ukcp> (accessed 11.01.2024)

The UKCP18 probabilistic projections are driven by emission scenarios rather than concentrations. This is different to most other projections that use general climate circulation models (see Watkiss and Betts, 2021). The UKCP18 calculates its own **concentration pathways, which raise faster than the standard representative concentration pathways** (RCP) for example from the Coupled Model Intercomparison Project (CMIP5).

UKCP18 includes **updated marine projections of sea level rise to 2100 and exploratory projections to 2300** (see 5.3.2 below). The methodologies for the marine projections in UKCP18 are described in detail in the UKCP Marine report (Palmer et al., 2018). The UKCP18 time-mean sea level projections are based on the approach of the IPCC Fifth Assessment Report (AR5) (Church et al., 2013). Future sea level rise projects are based on scenarios RCP2.6, RCP4.5 and RCP8.5 on the basis of the 5th and 95th percentiles of the underlying process-based model projections. According to IPCC AR5, this is the “likely range” with an approximately 60 percent chance of sea level rise falling within this model range. The UKCP18 considers that there may be a greater than 10 percent chance that actual sea level rise will lie outside these ranges and that this likelihood cannot be accurately quantified (Palmer et al., 2018).

The Marine Report also covers projections for waves and storm surges though there is still only limited information on these. One of the limitations for the storm surge and wave projections was the availability of high frequency CMIP5 climate model output needed to drive surge and wave model simulations.

Work is continuously ongoing to improve the UKCP projections. In March 2023, updates to the UKCP sea levels datasets were published:

- The 2023 update extends the spatial coverage of projections of future extreme sea levels to all open-coast coastal flood boundary point locations around the UK coastline, including 1) projected future 21st century time-mean sea level projections for 2020-2100 and 2) exploratory extended time-mean sea level projections for 2020-2300 (Met Office 2023).
- The sea level projections have been converted from the IPCC AR5 baseline of 1986-2005 to the UKCP18 baseline period of 1981-2000. The update resulted in a small adjustment (about a 1cm increase compared to the original data).

The Environment Agency currently uses the UKCP probabilistic projections for RCP8.5 in its guidance on managing sea level rise in England. The decision to use RCP8.5 was based on the consideration that this scenario was considered as realistic in the current global emissions policy context.¹⁸²

5.3.2 Exploratory sea level projections for the UK to 2300

In 2016, the Environment Agency, Scottish Environmental Protection Agency, Natural Resources Wales, the Welsh Government and Defra commissioned the Met Office to develop new projections of sea level rise for the UK out to the year 2300 (Howard et al., 2019b). The research was commissioned and funded through the Joint Flood and Coastal Erosion Risk Management Research and Development Programme which is jointly overseen by the above-listed institutions on behalf of all Risk Management Authorities in England and Wales.

The project developed experimental projections of **mean and extreme sea levels to the year 2300**, information that is seen as **critical for long-term planning** and the UK’s adaptation response to increasing sea levels. The work complements the updated projections of mean and extreme sea level rise

¹⁸² Interview with Environment Agency, 13.12.2023.

to 2100 developed under the UK Climate Projections 2018 (UKCP18) project. The data associated with this work are available through the **UKCP18 data portal**¹⁸³ and the results are incorporated in associated UKCP18 project publications. The project also carried out a literature review of past and future **expected impacts of climate change on waves**. Research is currently ongoing to make the projections to 2300 more robust and applicable in planning and decision making.

For the extended sea level rise projections to 2300, a simpler version of the model from the UKCP18 projections was constructed. The model was based on CMIP5 to ensure consistency between the 2100 and 2300 projections. Future extreme sea levels were produced for 46 UK tidal gauges using time series of mean sea level rise to 2300 and current best estimates of the return periods for observed sea levels. The project covered low, medium–low and high emission RCPs from IPCC AR5 (Figure 17). The method for exploratory extended sea level projections is described in Howard et al. (2019b) and the UKCP18 Marine Report (Palmer et al., 2018). An important aspect of these extended projections is that they can be used seamlessly with the UKCP18 21st century sea level projections. However, the extended projections are *exploratory* and there is a greater degree of unquantified uncertainty than there is with the UKCP18 21st century projections.

	Year	RCP2.6	RCP4.5	RCP8.5
UKCP18 21st century projections	2100	0.44 (0.29–0.67)	0.54 (0.38–0.79)	0.78 (0.56–1.12)
	2100	0.45 (0.30–0.68)	0.54 (0.36–0.79)	0.76 (0.53–1.12)
Extended projections (this report)	2200	0.8 (0.5–1.5)	1.1 (0.7–1.8)	1.8 (1.3–2.9)
	2300	1.1 (0.6–2.2)	1.5 (0.9–2.6)	2.7 (1.7–4.5)

Notes: The numbers given are the central estimates for the year indicated, with the 5th to 95th percentile range given in brackets. Numbers beyond 2100 are quoted to the nearest 0.1m, given the lower confidence associated with projections on these extended time horizons. Source: UKCP18 Marine Report (Palmer et al. 2018b, Table 4.2.1)

Figure 17. Comparison of the UKPC18 21st century global time-mean sea level projections and the extended projections presented in Chapter 2.3 of Howard et al. (2019b).

5.3.3 Evidence base for CCRA3

The Climate Change Committee uses the UKCP within its risk assessments. The introduction to the CCRA3 explains that UKCP18 was part of the evidence base for the CCRA3 as far as possible though the assessment was still largely based on UKCP09. This was due to the fact that much of the existing evidence on future UK climate change risks considered in the assessment is based on earlier projections.

The CCRA3 also included updated projections of future flood risk (Sayers et al., 2020). CCRA3 is framed in terms of **trajectories of global warming** rather than emissions scenarios. Research commissioned on some of the risks used selected components of the UKCP18 projections representing global warming of **approximately 2°C and 4°C at the end of the century**. The assessment of other risks drew on literature using other models, projections and scenarios that give approximately 2°C and 4°C global warming by

¹⁸³ www.metoffice.gov.uk/research/collaboration/ukcp/download-data (accessed 11.01.2024)

2100. The CCRA3 used two climate change scenarios to reflect these trajectories of global warming: **the 50th to 95th percentile range with RCP2.6 emissions as the lower scenario, and the 50th to 95th percentile range with RCP6.0 emissions as the higher scenario.** Most projections related to RCP8.5 were considered as low-likelihood, high-impact outcomes and were not included in the main assessment of CCRA3.

The NAP3 identifies a need to provide more specific climate projections for local government, including data on how climate risks map onto specific places in CCRA4 (2027) and trialling a local authority climate service to provide local projections.

5.3.4 The Flood and Forecasting Centre

The **Flood and Forecasting Centre**¹⁸⁴ is a dedicated team at the Met Office that works in partnership with the Environment Agency and Natural Resources Wales. The Flood and Forecasting Centre provides data, forecasts and information to the Environment Agency related to all natural forms of flooding related to rivers, surface water, groundwater and the sea. Services include a daily Flood Guidance Statement, which summarises the flood risk for the next five days, a public five-day forecast and a Flood Outlook for the coming month.

5.3.5 The coastal erosion risk map

The Environmental Agency has developed an online interactive **coastal erosion risk map**¹⁸⁵ (ArcGIS) for England that provides details on the predicted erosion rates for the **short term (up to 2025), medium term (up to 2055) and long term (up to 2105)**. The coastal erosion risk map is based on best available data. It shows the shoreline management plan for each stretch of coast (see Section 5.2.2) and erosion predictions where there is no policy to maintain defences. The coastline is divided into management units and the map allows to zoom in and click on the coastline to see details for each management unit.

For example, zooming in to the Norfolk coast, the map shows that the policy in many areas is ‘managed realignment’. The coast in this part of the country is characterised by sandy beaches, sand dunes, saltmarshes and cliffs and is experiencing high erosion rates. For the Southwest coastline, the map shows that the predominant policy is ‘no active intervention’ with some ‘hold the line’ policies in more urban areas. This part of the coast is characterised by steep, erodible cliffs and is sparsely populated. ‘No active intervention’ is also the predominant policy along parts of the Northeast coast that have high erosion rates but are sparsely populated. Lastly, zooming in to the Northwest coast around Liverpool Bay, the policy is mainly ‘hold the line’ of existing seawalls or natural defences. Again, the picture is similar along the densely urbanised Southeast coast.

¹⁸⁴ <https://www.gov.uk/government/organisations/flood-forecasting-centre> (accessed 11.01.2024)

¹⁸⁵ <https://www.gov.uk/check-coastal-erosion-management-in-your-area> (accessed 11.01.2024)

5.4 Financial Programs Related to Sea Level Changes

There are two government programmes that fund projects related to flooding and coastal erosion in England. Both programmes are managed by the Environment Agency and run from 2021 to 2027.

The programme of flood and coastal erosion risk management (FCERM) schemes¹⁸⁶ are a GBP 5.2 billion government investment programme to reduce flood and coastal erosion risk in England and protect 336,000 properties (including homes, public and private properties). The programme covers flooding from different sources including from the sea and funds projects for coastal defence in collaboration with local authorities, internal drainage boards and local communities.

The flood and coastal innovation programme¹⁸⁷ is a GBP 200 million flood and coastal resilience innovation fund. The fund allocates:

- GBP 150 million to the [flood and coastal resilience innovation programme](#) for projects in 25 local areas that will demonstrate practical innovative actions improve resilience to flooding and coastal erosion.
- up to GBP 36 million to the [coastal transition accelerator programme](#) for projects that support communities and businesses to adapt to coastal change.
- GBP 8 million to the [adaptation pathways programme](#) for work on long term planning for climate adaptation in the Thames and Humber estuaries, the Severn Valley and Yorkshire.

5.5 Success Stories and Challenges related to Sea Level Governance

In September 2021, a virtual workshop titled "The Science of Global and UK Sea-Level Projections: Progress Challenges and Future Directions"¹⁸⁸ was held among experts and stakeholders to discuss sea level projections and their implications for the UK. The available summary note (Palmer et al., 2021) provides some relevant takeaways:

- Need for a **coherent, long-term approach to planning** for sea level rise, considering difficult decisions such as **limiting the approval of new properties** and relocating existing properties.
- Need for information provision, regulatory/economic instruments, dedicated national funding, and monitoring and evaluation to manage the risks from sea level rise, as well as understanding the **complex interactions between sea level rise and other factors**.
- The importance of **national governments** prioritizing engagement and **providing necessary support to other levels of government**, and the significance of **cross-departmental collaboration** and sharing of lessons learned among local governments.
- Need for **improved sea level monitoring capabilities** to support climate research and adaptation strategies, recognising sea level rise as a critical climate change risk.

¹⁸⁶ <https://www.gov.uk/government/publications/flood-and-coastal-erosion-risk-management-an-investment-plan-for-2021-to-2027>; <https://www.gov.uk/government/publications/programme-of-flood-and-coastal-erosion-risk-management-schemes#full-publication-update-history> (accessed 11.01.2024)

¹⁸⁷ <https://www.gov.uk/guidance/flood-and-coastal-resilience-innovation-programme>; <https://engageenvironmentagency.uk.engageenthq.com/hub-page/fcrmfund> (accessed 11.01.2024)

- Emphasis on the **importance of continuous sea level projections** (not just levels at points in time) for informed coastal management and planning.
- The significance of quantifying local relative mean sea level change for risk, impact and adaptation assessments and for coastal decision-making, and the need for further investigation into the potential impacts of sea level rise on coastal flood events.
- Remaining **challenges in communication and application of sea level projections** among stakeholders, including policy implications and public perception.
- The importance of **engaging a broad range of stakeholders**, including youth and community-based organizations, in the development of coastal management and effective adaptation strategies.

Several of these points were also echoed in the experiences and reflections shared by our UK informants:

- Having derived **scenarios for longer time period up till 2300** has proven very useful. The Environment Agency strongly argued that in particularly for coastal adaptation, a longer time frame is needed and therefore co-funded a project in addition to the core funding that was coming from government to extend the projections out from 2100 out to 2300. **These extended projections have proven valuable related to national infrastructure**, particularly on coastal contexts.
- **The Thames Estuary 2100 Plan** is an example of an **adaptive pathways approach** that is dynamic and adaptive to future changes and that can incorporate the latest scientific data and projections, based on regular review and update processes. It relies on collaborative governance to ensure the long-term resilience of the estuary against the challenges posed by climate change and sea level rise.
- Working on **the communication of the scientific knowledge** underpinning the adaptation advice and guidelines related to sea level rise, storm surges and wave impacts is **a central component of the adaptation governance work**. This entails both translating the raw climate change projections into relevant information for policy and adaptation guidance and making the scientific information externally available for adaptation actions.
- There are areas in which the **scientific knowledge base still needs to be improved**. For example, knowledge and guidance on waves and tides in the UKCP18 marine report need to be further developed. This will **require additional research** as it is quite complicated to understand how tides and waves will change in the future. It is also difficult to understand how changes in sea level height will affect tidal systems. Within the UK, the tidal ranges are different for different parts of the coast. It will be important to understand how tides and waves might change in different locations and whether there are any trends that are more generally applicable to the entire country.
- There is a gap in funding in England regarding **funding mechanisms to facilitate managed retreat** that might be a necessary adaptation step in some areas in the future.

6 Synthesizing Governance of Sea Level Changes in Denmark, the Netherlands and the United Kingdom

This chapter synthesizes the key findings from Denmark, the Netherlands and the United Kingdom (UK), presented in the previous chapters, highlighting their sea level governance structures, strategies, and experiences, focusing both on adaptation to long-term sea level changes and the immediate impacts of storm surges and wave impacts. It is important to note that this is not a comparative analysis, but rather a synthesis of the main approaches from each country (see overview in Table 1 further below).

Denmark: Integrated Coastal Management, Community Engagement and Beneficiary Contributions

Denmark's approach to sea level governance is characterized by its integrated coastal management strategy, encompassing both structural measures (like dikes and sea walls) and non-structural methods (such as beach nourishment). Decentralisation is key in the Danish approach, with a strong emphasis on **local community involvement and decentralized decision-making**. Through a 2018 agreement, municipalities have been designated the responsibility and mandate over coastal protection. This is further detailed in the **2023 Climate Adaptation Plan 1 presented by the national government**, which particularly targets municipalities and property- and landowners. Furthermore, with the revised Planning Act of 2018, municipalities became legally obliged to consider flooding and coastal erosion in their spatial planning. In these processes, communities, commonly landowner organizations, are often engaged in planning and implementation phases of coastal protection projects, reflecting a bottom-up approach. Additionally, an important facet of Denmark's model is the principle that **beneficiaries of coastal protection measures contribute to covering the costs**. This approach acknowledges that while public funds are used for general protection, specific enhancements or protections that benefit private property owners require their financial participation. This system encourages local stakeholders to carefully consider the necessity and scope of protection measures. Some financial support is available to municipalities and private property owners. Municipalities can apply for support for coastal protection projects from a temporary financial pool and private property owners can apply for funds to cover damages from storm surges. A blend of **community-based, decentralized governance, and financial contributions from beneficiaries** forms the core of Denmark's adaptive and participatory approach to managing sea level changes.

The Netherlands: Centralized Governance, Adaptive Strategies, and Collaborative Comprehensive Knowledge Programs

The Netherlands' approach to sea level governance is a result of its world-renowned expertise in water management. The **approach is centralized**, with the **national government**, particularly through the national agency *Rijkswaterstaat* (the operative body of the Ministry of Infrastructure and Water Management) and the Delta Programme, playing pivotal roles. The Rijkswaterstaat focuses on national water bodies and large infrastructures like storm surge barriers, and the coastline. The Delta Programme is dedicated to stimulating timely execution of policies and the development of long-term strategic decision-making and adaptive planning. Even with a centralised approach, importantly, there is **strong regional participation of the water boards**, provinces, local governments and other stakeholders.

The Dutch approach is characterized by the concept of **adaptive governance and adaptive Delta management**, focusing on exploring multiple futures and **identifying short-term actions alongside long-term options**. The approach entails continuously updating and refining policies based on new scientific insights and climate projections. This ensures that the country's defences remain robust against future sea level rise and extreme weather events with storm surges and wave impacts. This process of adaptive governance is facilitated by the **Knowledge Program on Sea Level Rise**, a collaborative initiative under the **Ministry of Infrastructure and Water Management** and the **Delta Programme** that integrates research and analysis from various actors, including Deltares. Deltares is an independent, not-for-profit research institute that provides analyses and advice for the Delta Programme, particularly on modelling and strategizing long-term adaptation to sea level rise. Another aspect of the Netherlands' approach is risk-based planning, which assumes equal risks across the population and strives to maintain this equilibrium through various **adaptation pathways**. This approach, however, is evolving to also include low likelihood but high-impact scenarios, prompting discussions on longer-term projections and adaptation commitments beyond 2100. Financial mechanisms related to sea level changes include the Delta Fund, subsidies, and funding raised through taxes based on the **solidarity principle**.

The United Kingdom: Risk Management, Regional Adaptation and Comprehensive National Strategies

The UK's approach to managing sea level rise and storm surges is characterized by a combination of **regional adaptation plans and comprehensive national strategies**. This approach is necessitated by the UK's extensive and varied coastline, which presents distinct challenges in different regions. The legal framework for addressing these challenges is established through **the Climate Change Act of 2008**, complemented by regional legislation and policies. The Act mandates regular assessments of climate change risks. These assessments inform the development of **National Adaptation Programmes (NAP)** that outline specific actions for adaptation. The UK also focuses on **regularly updating its policies** and practices based on new scientific insights and climate projections. This includes investment in research and public awareness campaigns about sea level rise and risks of coastal flooding and erosion. In England, the Environment Agency plays a key role in strategic risk management and offers guidance on local planning and environmental assessments concerning flood risk and coastal erosion. Similar responsibilities are undertaken by respective authorities in Scotland, Wales, and Northern Ireland.

Local planning is integral to the UK's approach, with local coastal protection authorities responsible for managing coastal flood and erosion risk in their areas. The UK applies a **risk-based, sequential approach** to integrating flood risk and erosion in local planning, **emphasizing avoidance of development in high-risk areas** and adapting to coastal changes. Strategic policies for coastal adaptation and risk management in the short-, medium- and long-term are set out by local authorities in **shoreline management plans**. Depending on the particular context of the section of coast, the policy may be 'hold the line', 'managed realignment', 'no active intervention' or 'advance the line'. Government financed programmes, such as the Flood and Coastal Erosion Risk Management Investment Programme, provide funding for projects aimed at mitigating coastal risks and adapting to coastal change. The UK's strategy also benefits from scientific programmes like the Met Office Hadley Centre Climate Programme that provides the **UK Climate Projections 2018 (UKCP18)**, offering detailed projections for sea level rise and storm surges to inform policy and planning decisions. Overall, the UK's governance model for sea level changes combines **national strategic policies and planning guidance with local, region-specific adaptation measures**, reflecting the diverse nature of its coastal challenges.

The key aspects for each of the countries are summarised in the table below.

Table 1. Summary of key aspects from the mapping of sea level governance in the three countries.

Aspect	Denmark	The Netherlands	The UK
Key actors responsible	<p><u>National policy actors:</u> Ministry of Environment of Denmark, Danish Nature Agency, the Danish Environmental Protection Agency</p> <p><u>National coastal authority:</u> The Danish Coastal Authority (DCA)</p> <p><u>Other risk management actors:</u> Danish Natural Hazards Council</p> <p><u>Local actors:</u> Landowners and citizens are responsible for protecting their coastal properties</p> <p><u>Knowledge base:</u> DMI; GEUS, SDFI, cross-sectoral actors contributing to the climate adaptation portal <i>klimateilpasning.dk</i></p>	<p><u>National independent actor:</u> Delta Commissioner</p> <p><u>National policy actor:</u> Ministry of Infrastructure and Water Management</p> <p><u>National executive agency:</u> Rijkswaterstaat</p> <p><u>Regional actors:</u> Water boards</p> <p><u>Knowledge base:</u> KNMI, Deltares and other knowledge actors (Signal group, universities)</p>	<p><u>National policy:</u> Department of Environment, Food and Rural Affairs, Climate Change Committee</p> <p><u>National risk management authority:</u> Environment Agency</p> <p><u>Coastal protection authorities:</u> District councils and unitary authorities</p> <p><u>Other risk management authorities:</u> County councils, internal drainage boards</p> <p><u>Knowledge base:</u> Met Office Hadley Centre</p>
Key regulation, policies, strategies, programs	<p>The Coastal Protection Act (<i>Kystbeskyttelsesloven</i>),</p> <p>The Planning Act (<i>Planloven</i>),</p> <p>The Floods Acts (<i>Oversvømmelsesloven</i>)</p>	<p>National Water Programme,</p> <p>National Adaptation Strategy,</p> <p>The Delta Programme: dedicated to stimulating timely execution of policies</p>	<p>Flood and Coastal Risk Management Policy Statement,</p> <p>Flood and Coastal Erosion Risk Management Strategy,</p> <p>Shoreline management plans,</p> <p>Flood risk management plans,</p> <p>National Planning Policy Framework</p>
Governance set-up	Decentralised and community-based	Centralised, but with strong collaboration with regional actors and water boards	Decentralised and devolved, national-level policy frameworks with local government implementation (two tiers, single tier)
Key governing principles	Risk-based approach, Private beneficiaries cover costs of coastal protection measures	Adaptive pathways approach, Risk-based approach (complement each other well), Solidarity principle	Risk-based approach, Sequential planning
Knowledge base – timelines, projections, scenarios used	Nationwide mapping by DCA of the risk of coastal flooding with projections up until 2120, three time-perspectives are assessed: present (2020), 50-year (2070) and 100-year (2120). SLR projections up until 2150 available from DMI	Sea Level Rise Knowledge Program, KNMI Scenarios23: Projections up until 2300, including likely scenarios for all climate parameters and low-likelihood high impacts and SLR scenarios	UKCP18 and UKCP Marine Report Projections up until 2100 Experimental projections up until 2300 (ongoing work)
Financial mechanisms and tools	<p>The Danish Coastal Protection law permits municipalities to request payment from property owners for storm surge adaptation</p> <p>Storm surge damages compensation scheme available for citizens</p> <p>Coastal municipalities can apply for financial support for projects from a temporary coastal protection pool managed by the DCA</p>	<p>Delta Fund – including systematic funding of sea level governance, maintenance of water/delta works</p> <p>Solidarity principle: Funding of measures and actions through taxes and subsidies.</p>	<p>Programme of flood and coastal erosion risk management (FCERM) schemes 2021-27 (GBP 5.2 billion government investment in coastal defense projects)</p> <p>Flood and coastal innovation programmes 2021-27 (GBP 200 million flood and coastal resilience innovation fund)</p>

While direct recommendations are beyond the scope of this report, the examples from Denmark, the Netherlands, and the UK may offer valuable insights and possible approaches to be inspired by as Norway continues to develop its sea level governance framework. The sea level governance strategies of these three countries reflect their geographic and socio-economic contexts. Yet, a recurring theme in all countries is the emphasis on the need for **cross-sector collaboration and adaptability, including staying responsive to emerging challenges and scientific advancements.**

All three countries face challenges in upgrading and maintaining infrastructure to withstand the increased risks from sea level rise, storm surges, and wave impacts. Informants in all three countries point to **enhancing stakeholder engagement and public awareness** for successful governance, emphasizing the inclusion of various actors in decision-making and improving public understanding of sea level change risks and necessary adaptations. Our study points to the relevance of **integrated policy frameworks that balance immediate protective actions with long-term adaptation strategies,** considering economic, ecological and social factors.

7 References

- Amey Consulting. (2019). *Baseline Study and Gap Analysis of Coastal Erosion Risk Management NI*. Report prepared by Amey Consulting with HR Wallingford for the Department for Infrastructure (DfI) and the Department of Agriculture, Environment and Rural Affairs (DAERA), Northern Ireland. Retrieved from <https://www.infrastructure-ni.gov.uk/publications/baseline-study-and-gap-analysis-coastal-erosion-risk-management-ni>
- Betts, R.A., & Brown, K. (2021). Introduction. In R.A. Betts, A.B. Haward, & K.V. Pearson (Eds.), *The Third UK Climate Change Risk Assessment Technical Report*. Prepared for the Climate Change Committee, London. Retrieved from <https://www.ukclimaterisk.org/publications/technical-report-ccra3-ia/>
- Bisaro, A., de Bel, M., Hinkel, J., Kok, S., Stojanovic, T., & Ware, D. (2020). Multilevel governance of coastal flood risk reduction: A public finance perspective. *Environmental Science & Policy*, 112, 203-212 <https://doi.org/10.1016/j.envsci.2020.03.006>
- Bloemen, P.J.T.M., Hammer, F., Van der Vlist, M.J., Grinwis, P., & Van Alphen, J. (2019). DMDU into practice: Adaptive Delta Management in the Netherlands. In Marchau et al. (Eds.), *Decision Making under Deep Uncertainty: From Theory to Practice*. Springer International Publishing. pp. 321–351.
- Bosoni, M., Tempels, B., & Hartmann, T. (2021). Understanding integration within the Dutch multi-layer safety approach to flood risk management. *International Journal of River Basin Management*. <https://doi.org/10.1080/15715124.2021.1915321>
- Church, J.A., Clark, P.U., Cazenave, A., Gregory, J.M., Jevrejeva, S., Levermann, A., Merrifield, M.A., Milne, G.A., Nerem, R.S., Nunn, P.D., Payne, A.J., Pfeffer, W.T., Stammer, D., & Unnikrishnan, A.S. (2013). Sea Level Change. In T.F. Stocker et al. (Eds.), *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.
- Committee on Climate Change. (2018). *Managing the coast in a changing climate*. Retrieved from <https://www.theccc.org.uk/publication/managing-the-coast-in-a-changing-climate/>
- Dawson, A., & Verweij, M. (2012). Solidarity: A Moral Concept in Need of Clarification. *Public Health Ethics*, 5(1). <https://doi.org/10.1093/phe/phs007>
- Deltaprogram 2024. (2024). *Deltaprogramma 2024 | Waterveiligheid*. Retrieved from <https://www.deltaprogramma.nl/>
- Environment Agency. (2020). *National Flood and Coastal Erosion Risk Management Strategy for England*. Retrieved from <https://www.gov.uk/government/publications/national-flood-and-coastal-erosion-risk-management-strategy-for-england>
- Fitton, J. M., Addo, K. A., Jayson-Quashigah, P. N., Nagy, G. J., Gutiérrez, O., Panario, D., & Stempel, P. (2021). Challenges to climate change adaptation in coastal small towns: Examples from Ghana, Uruguay, Finland, Denmark, and Alaska. *Ocean & Coastal Management*, 212. <https://doi.org/10.1016/j.ocecoaman.2021.105787>
- Glavovic, B., Dawson, R., Chow, W., Garschagen, M., Haasnoot, M., Singh, C., & Thomas, A. (2022). Cross-Chapter Paper 2: Cities and Settlements by the Sea. In: *Climate Change 2022: Impacts, Adaptation, and Vulnerability*. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. <https://doi.org/10.1017/9781009325844.019>
- Gram Hanssen, I., Aall, C., Drews, M., Juhola, S., Jurgilevich, A., Klein, R. J. T., Mikaelsson, M. A., & Lyngtorp Mik-Myer, V. (2023). Comparison and analysis of national adaptation policies in the Nordic region (TemaNord 2023:525). Nordic Council of Ministers. <https://doi.org/10.6027/temanord2023-525>
- Haasnoot, M., Van het Klooster, & J. Van Alphen. (2018). Designing a monitoring system to detect signals to adapt to uncertain climate change. <https://doi.org/10.1016/j.gloenvcha.2018.08.003>
- Haasnoot, M., Bouwer, L., Diermanse, F., Kwadijk, J., van der Spek, A., Oude Essink, G., Delsman, J. Weiler, O.,

- Mens, M., ter Maat, J., Huismans, Y., Sloff, K., Mosselman, E. (2018). *Mogelijke gevolgen van versnelde zeespiegelstijging voor het Deltaprogramma. Een verkenning*. Deltares rapport 11202230-005-0002.
- Haasnoot, M., Diermanse, F., Kwadijk, J., de Winter, R., & Winter, G. (2019). *Strategieën voor adaptatie aan hoge en versnelde zeespiegelstijging. Een verkenning*. Deltares rapport 11203724-00. Retrieved from <https://www.deltares.nl/en/publications/strategieen-voor-adaptatie-aan-hoge-en-versnelde-zeespiegelstijging/>
- Haasnoot, M., Kwadijk, J., Van Alphen, J., Le Bars, D., Van Den Hurk, B., Diermanse, F., ... Mens, M. (2020). Adaptation to uncertain sea-level rise; how uncertainty in Antarctic mass-loss impacts the coastal adaptation strategy of the Netherlands. *Environmental Research Letters*, 15(3), 034007. <https://iopscience.iop.org/article/10.1088/1748-9326/ab666c>
- Howard, T., Palmer, M.D., & Bricheno, L.M. (2019a). Contributions to 21st century projections of extreme sea-level change around the UK. *Environmental Research Communications*, 1(9), 095002. Retrieved from <https://iopscience.iop.org/article/10.1088/2515-7620/ab42d7>
- Howard, T., Palmer, M., Guentchev, G., & Krijnen, J. (2019b). Exploratory sea level projections for the UK to 2300. Environment Agency. Retrieved from <https://www.gov.uk/government/publications/exploratory-sea-level-projections-for-the-uk-to-2300>
- Maas, H., & Surian, J. (2023). Dutch national climate change adaptation policy through a securitization lens: Variations of securitization. *Frontiers in Climate*, 5. <https://doi.org/10.3389/fclim.2023.1080754>
- Madsen, K. S., Murawski, J., Blokhina, M., & Su, J. (2019). Sea level change: Mapping Danish municipality needs for climate information. *Frontiers in Earth Science*, 7, 81. <https://doi.org/10.3389/feart.2019.00081>
- Met Office. (2023). UKCP18 Factsheet: Sea-level rise and storm surge - supplementary data. Retrieved from https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18_factsheet_sea_level_rise_storm_surge_supp_data_mar23.pdf
- National Water Programme. (2022-2027). Documenten Nationaal Water Programma 2022-2027. Retrieved from <https://iplo.nl/documenten-nationaal-water-programma/>
- Norwegian Ministry of Climate and Environment. (2022-2023). *Klima i endring - sammen for et klimarobust samfunn*. Meld. St. 26 (2022–2023). Retrieved from <https://www.regjeringen.no/contentassets/1008d2a2e92c4384890817fae9fca1d4/no/pdfs/stm202220230026000dddpdfs.pdf>
- Natural Resources Wales. (2021). Shoreline Management Plans: Supplementary guidance for their ongoing maintenance and delivery – Wales. NRW Evidence Report. Retrieved from <https://naturalresources.wales/media/694585/shoreline-management-plans-supplementary-guidance-for-their-ongoing-maintenance-and-delivery-in-wales.pdf>
- Office of the Auditor General of Norway. (2022). Investigation into government authorities' effort to adapt infrastructure and built-up areas to a changing climate (Document 3:6 [2021-2022]). Retrieved from <https://www.riksrevisjonen.no/globalassets/reports/en-2021-2022/document-3-6-2021-2022---investigation-into-government-authorities-effort-to-adapt-infrastructure-and-built-up-areas-to-a-changing-climate.pdf>
- Oppenheimer, M., Glavovic, B.C., Hinkel, J., van de Wal, R., Magnan, A.K., Abd-Elgawad, A., Cai, R., Cifuentes-Jara, M., DeConto, R.M., Ghosh, T., Hay, J., Isla, F., Marzeion, B., Meyssignac, B., & Sebesvari, Z. (2019). Sea Level Rise and Implications for Low-Lying Islands, Coasts and Communities. In H.-O. Pörtner et al. (Eds.), *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate* (pp. 321-445). Cambridge University Press. <https://doi.org/10.1017/9781009157964.006>
- Palmer, M., Howard, T., Tinker, J., Lowe, J., Bricheno, L., Calvert, D., Edwards, T., Gregory, J., Harris, G.,

- Krijnen, J., Pickering, M., Roberts, C., & Wolf, J. (2018). UKCP18 Marine report. Retrieved from <https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-marine-report-updated.pdf>
- Palmer, M., Allison, L., Bingham, R., Bradshaw, E., Harrison, B., Le Brocq, A., Lowe, J., Malagon Santos, V., Slangen, A., & Weeks, J. (2021). The Science of Global and UK Sea-Level Projections: Progress, Challenges and Future Directions. Workshop Report. Retrieved from https://blogs.exeter.ac.uk/sealevelworkshop/files/2021/10/SeaLevelWorkshop_Report_22.11.21.pdf
- Sayers, P.B., Horritt, M.S., Carr, S., Kay, A., Mauz, J., Lamb, R., & Penning-Rowsell, E. (2020). *Third UK Climate Change Risk Assessment (CCRA3): Future flood risk*. Research undertaken by Sayers and Partners for the Committee on Climate Change. Published by Committee on Climate Change, London. Retrieved from <https://www.ukclimaterisk.org/wp-content/uploads/2020/07/Future-Flooding-Main-Report-Sayers-1.pdf>
- SEPA. (2023). *Climate change allowances for flood risk assessment in land use planning*. Version 3. Retrieved from <https://www.sepa.org.uk/media/594168/climate-change-guidance.pdf>
- Sustainability West Midlands. (2021). Evidence for the third UK Climate Change Risk Assessment (CCRA3). Summary for England. Retrieved from <https://www.ukclimaterisk.org/publications/summary-for-england-ccra3-ia/#site-main>
- Swinkels, & Raadgever. (2022). Ruimtelijke besluitvorming voor een onzekere toekomst. Inventarisatie van de rol van zeespiegelstijging in de ruimtelijke besluitvorming in drie pilotgebieden, for the Ministerie van Infrastructuur en Waterstaat. Retrieved from <https://www.deltaprogramma.nl/binaries/deltacommissaris/documenten/publicaties/2022/09/01/kennisprogramma-zeespiegelstijging-ruimtelijke-besluitvorming-voor-een-onzekere-toekomst/NL22-648800269-30959.pdf>
- UK Government. (2010). Flood and Water Management Act 2010. Retrieved from <https://www.legislation.gov.uk/ukpga/2010/29/contents>
- Van Alphen, J., Haasnoot, M., & Diermanse, F. (2022). Uncertain Accelerated Sea-Level Rise, Potential Consequences, and Adaptive Strategies in The Netherlands. *Water*, 14(15), 1527. <https://doi.org/10.3390/w14101527>
- Van de Wal, R.S., Nicholls, R.J., Behar, D., McInnes, K., Stammer, D., Lowe, J.A., Church, J.A., DeConto, R., Fettweis, X., Goelzer, H., & Haasnoot, M. (2022). A High-End Estimate of Sea Level Rise for Practitioners. *Earth's Future*, 10(11), e2022EF002751. <https://doi.org/10.1029/2022EF002751>
- Van Rijswijk, M., & Salet, W. (2012). Enabling the contextualization of legal rules in responsive strategies to climate change. *Ecology and Society*, 17(2), 18. <http://dx.doi.org/10.5751/ES-04895-170218>
- Wang, Z.B., Elias, E.P.L., Van der Spek, A.J.F., & Lodder, Q.J. (2018). Sediment budget and morphological development of the Dutch Wadden Sea: Impact of accelerated sea-level rise and subsidence until 2100. *Netherlands Journal of Geosciences*, 97, 183–214.
- Watkiss, P., & Betts, R.A. (2021). Method. In R.A. Betts, A.B. Haward, & K.V. Pearson (Eds.), *The Third UK Climate Change Risk Assessment Technical Report*. Prepared for the Climate Change Committee, London. Retrieved from <https://www.ukclimaterisk.org/publications/technical-report-ccra3-ia/>
- Welsh Government. (2020). *The National Strategy for Flood and Coastal Erosion Risk Management in Wales*. Retrieved from <https://www.gov.wales/national-strategy-flood-and-coastal-erosion-risk-management-wales>

Appendix

Appendix A. List of interviews with informants

The informants are listed below by name based on their written consent. The individual informants are not cited directly in the report.

Denmark

Informant from the Danish Environmental Protection Agency (DEPA) – 14.11.2023

Two informants from the National Association of Municipalities (Kommunernes Landsforening) (joint meeting)–23.11.2023

Kaija Jumppanen Andersen, Specialist consultant climate and coastal protection, the Danish Coastal Authority (DCA, Kystdirektoratet) – 24.11.2023

Associate Professor Lars Bodum, Landinspektør, Cand. Geom. Dep. of Sustainability and Planning, Aalborg University - 26.09.2023 and 19.12.2023

The Netherlands

Marjolijn Haasnoot, Researcher climate change adaptation and water management at Deltares and Professor at Utrecht University – 8.11.2023

Dick Boland, Climate adaptation advisor- Rijkswaterstaat – 10.11.2023

Representative from the Dutch Ministry of Infrastructure and Water Management – 17.11.2023

United Kingdom

Leslie Mabon, Lecturer in Environmental Systems, Open University (UK) – 9.11.2023

Three representatives from the Environment Agency in the UK (joint meeting) – 13.12.2023:

- Andrew Eden, Flood and Coastal Risk Manager/ Programme Leader Adaptation and Resilience
- Stuart Allen, Principal Scientist, Climate Change and Resource Efficiency, Chief Scientist Group
- Andy Beverton, Research Scientist, Climate Change and Resource Efficiency, Chief Scientist Group

Appendix B. Glossary - Key terms in local language

Terminology	Norwegian	Danish	Dutch
Sea level rise	Havnivåstigning	Havniveaustigning	Zeespiegelstijging
Storm surge	Stormflod	Stormflod	Stormvloed
Storm surge events	stormflodhendelser	stormflodshændelser	stormvloedgebeurtenissen
Wave impacts	Bølgepåvirkning	Bølgepåvirkning	golven
Rising water level	Stigende havnivå	Stigende vandstand	Stijgend waterpeil
Floods	Flom	Oversvømmelser	Overstromingen
Climate change	Klimaendringer	Klimaændringer	Klimaatverandering
Climate adaptation	Klimatilpasning	Klimatilpasning	Klimaatadaptatie
Coastal erosion	Kysterosjon	Kysterosion	Kusterosie
Adaptation and mitigation	Tilpasning og utslippsreduksjon	Tilpasning og modvirkning	Adaptatie and mitigatie



The Norwegian Institute for Water Research

We are Norway's premier research institute in the fields of water and the environment. We are experts on ecosystems in both freshwater and marine environments, from mountains, lakes and rivers, to fjords, coasts and oceans. We develop science-based knowledge and solutions to challenges related to the interaction between water and climate, the environment, nature, people, resources and society.