Responding to Rising Seas

OECD Country Approaches to Tackling Coastal Risks

POLICY HIGHLIGHTS

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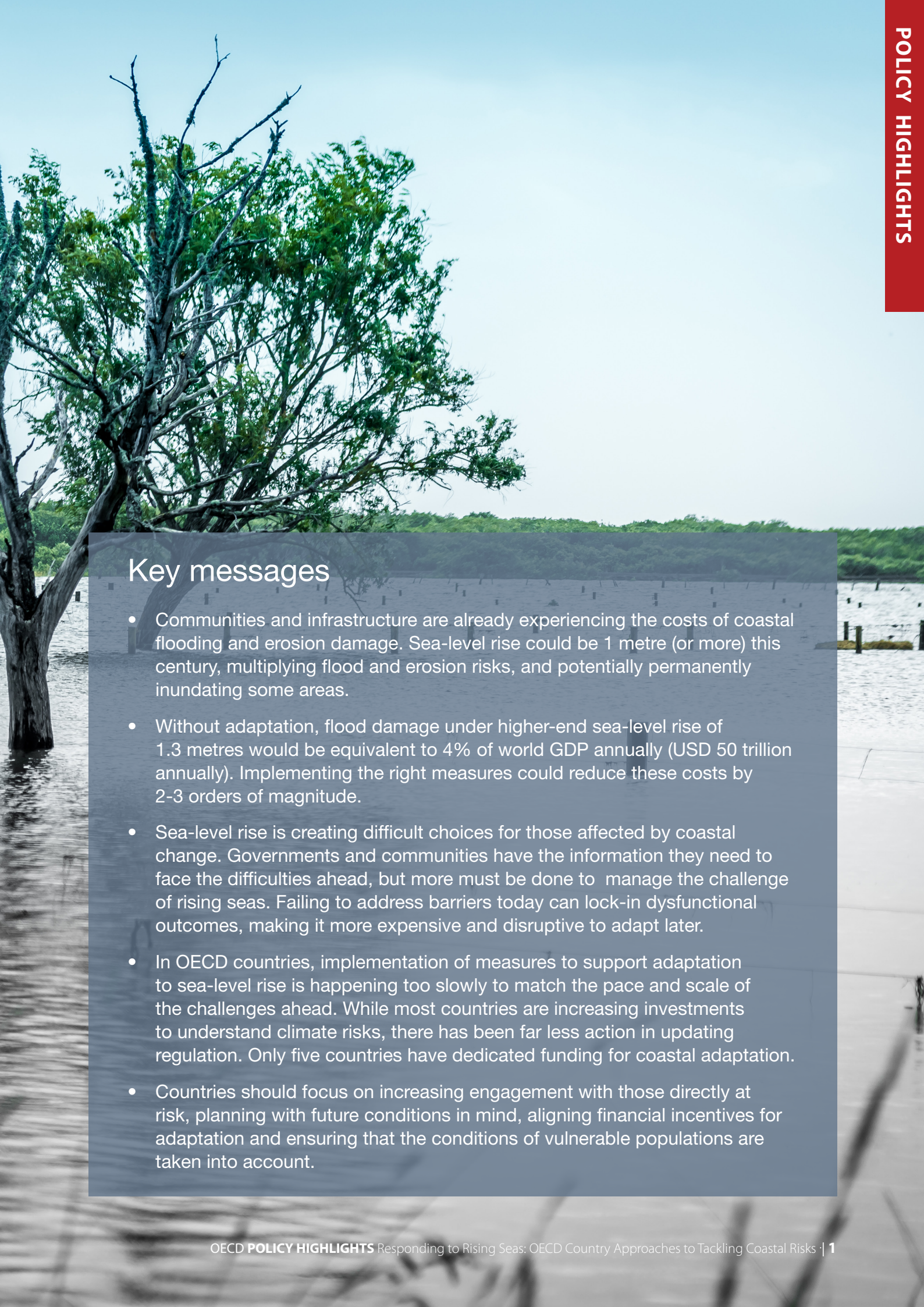
Foreword

Sea-level rise is one of the major challenges identified in the recent Intergovernmental Panel on Climate Change's Special Report "Global Warming of 1.5°C". It is almost certain that we will experience at least one metre of sea-level rise, with some models estimating this will happen within the next 80 years. This will have serious implications for damage to infrastructure, loss of land and displacement of communities. Even if we succeed in limiting the temperature increase to 1.5 degrees, sea levels will continue to rise for centuries to come, due to emissions we have already locked in. While living on the coast has always come with a certain level of flooding and erosion risks, climate change will alter our coastlines and we must prepare for this new reality.

This report, Responding to Rising Seas: OECD Country Approaches to Tackling Coastal Risks takes a major step forward in providing policy guidance on how countries can more effectively manage the risks from sea-level rise. The report takes stock of what OECD countries are currently doing to prepare for coastal change, and puts forward a policy framework for coastal adaptation that is equipped to meet the challenges of ever-increasing global temperatures. Four case studies – Canada, Germany, New Zealand and the United Kingdom – provide in depth examples of the challenges and success factors of coastal adaptation strategies under different institutional contexts. This report builds on the body of OECD work on managing climate risks.

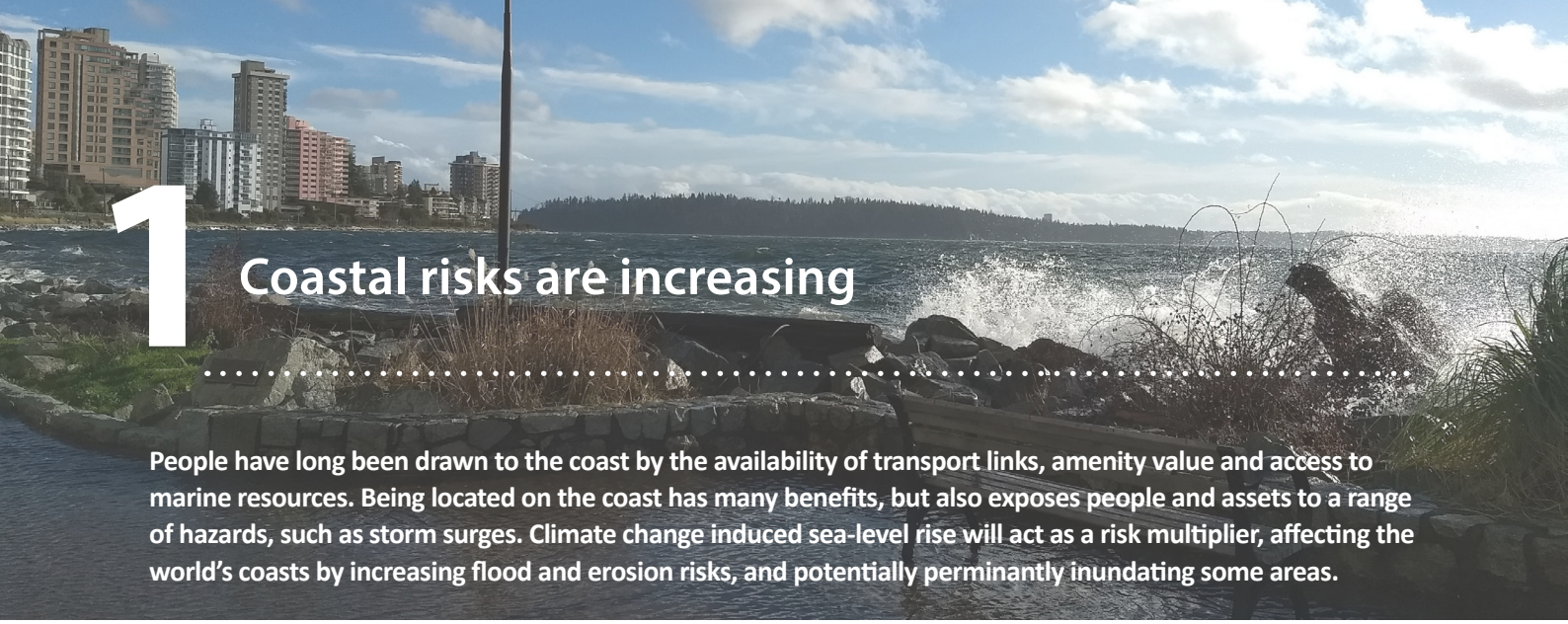
It is vital that countries strengthen their ability to understand, plan for and continuously manage climate risks. There is some progress – more and more OECD countries are developing national strategies to cope with climate change, and sub-national and private actors are also increasingly tackling this issue. However, there is a pressing need to translate planning into implementation. This OECD report provides lessons learned and guidance for countries in approaching the challenges from climate change that will surely mount over coming years.

Rodolfo LACY
Director, OECD Environment Directorate



Key messages

- Communities and infrastructure are already experiencing the costs of coastal flooding and erosion damage. Sea-level rise could be 1 metre (or more) this century, multiplying flood and erosion risks, and potentially permanently inundating some areas.
- Without adaptation, flood damage under higher-end sea-level rise of 1.3 metres would be equivalent to 4% of world GDP annually (USD 50 trillion annually). Implementing the right measures could reduce these costs by 2-3 orders of magnitude.
- Sea-level rise is creating difficult choices for those affected by coastal change. Governments and communities have the information they need to face the difficulties ahead, but more must be done to manage the challenge of rising seas. Failing to address barriers today can lock-in dysfunctional outcomes, making it more expensive and disruptive to adapt later.
- In OECD countries, implementation of measures to support adaptation to sea-level rise is happening too slowly to match the pace and scale of the challenges ahead. While most countries are increasing investments to understand climate risks, there has been far less action in updating regulation. Only five countries have dedicated funding for coastal adaptation.
- Countries should focus on increasing engagement with those directly at risk, planning with future conditions in mind, aligning financial incentives for adaptation and ensuring that the conditions of vulnerable populations are taken into account.



1 Coastal risks are increasing

People have long been drawn to the coast by the availability of transport links, amenity value and access to marine resources. Being located on the coast has many benefits, but also exposes people and assets to a range of hazards, such as storm surges. Climate change induced sea-level rise will act as a risk multiplier, affecting the world's coasts by increasing flood and erosion risks, and potentially perminantly inundating some areas.

As risks from sea-level rise increase, so do associated economic and human costs from extreme events and slow-onset changes. Without adaptation, flood damage under higher-end sea-level rise (1.3 metres) would be approximately 4% of world GDP annually (USD 50 trillion annually). This will strain society's capacity to maintain an acceptable level of risk at reasonable cost in coastal zones.

Physically, sea-level rise differs from existing coastal change due to:

- uncertainty around the magnitude and pace of change;
- long timescales.

Both uncertainty and long timescales contribute to low risk awareness in coastal zones - many inhabitants of flood prone areas are not aware of new and long-term risks. In addition, the time lag between when costs are incurred to reduce risks, and benefits are realised, as well as the public good nature of adaptation investments, can prevent sea-level rise risks from being internalised into decisions. This can lead to excessive exposure and vulnerability in coastal zones.

Coastal adaptation can significantly reduce costs – implementing coastal protection can reduce damage costs by 2-3 orders of magnitude. However, these measures also represent a significant investment and could cost up to USD 70 billion by 2100.

Modelling demonstrates that coastal protection is economically robust for 13% of the world's coastline – which accounts for 90% of the global coastal population and 96% of global assets. An implication of this is that the world is likely to see bifurcating coastal futures. On the one hand, the large majority of coastal inhabitants live in densely populated urban coastal areas, and are likely to continue to protect themselves even under high-end sea-level rise due to the high cost-benefit ratios of coastal protection in these areas. This means engineered coasts with higher and higher defences, and possible catastrophic consequences in the case of sea wall failure. On the other hand, rural and poorer areas will struggle to maintain safe human settlements and will likely be forced to retreat from the coast.

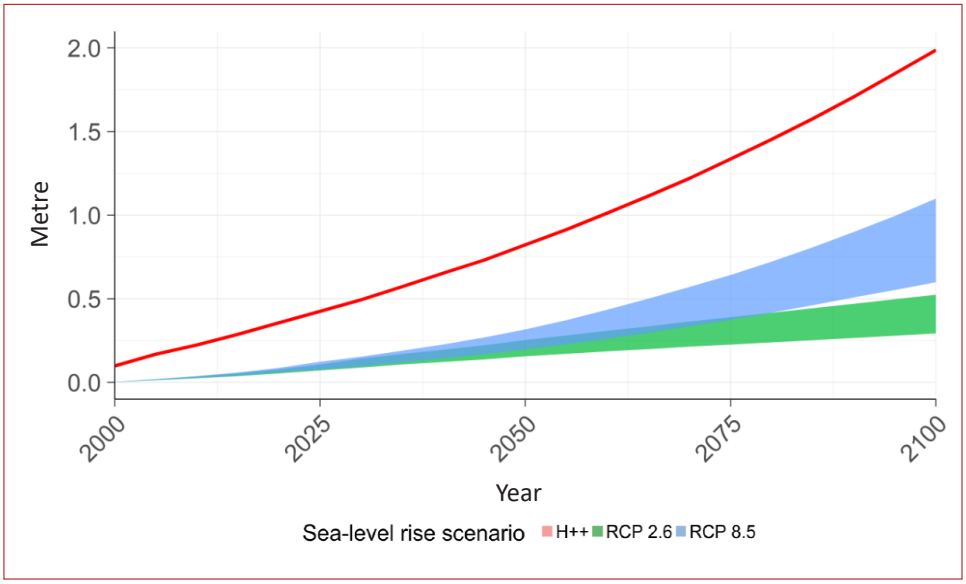
Sea-level increases are driven by changes in global mean temperature, which are in turn driven by atmospheric greenhouse gas concentrations. Projecting future sea levels requires developing sea-level rise scenarios based on different greenhouse gas concentration pathways. Representative concentration pathways (RCP) cover a wide range of potential future concentration pathways out to 2100. The figure on the next page shows possible sea-level rise under different concentration pathways. It also includes a scenario of up to 2 m of rise by 2100, based on a high-end sea-level rise scenario (H++).

A key challenge of coastal adaptation is that decisions made now have long-term implications, but we are preparing for a highly uncertain future. For example, the largest potential future contributors to sea-level rise are the melting of the Antarctic and Greenland ice sheets. However, estimates vary widely as to what the timing and size of this melt will be. Current estimates range between 25 cm to 2 m by 2100 (represented by H++), depending in part on future emissions.

The loss of biodiversity, ecosystem functions and coastal vegetation has contributed to increased vulnerability to coastal flooding. For example, 50% of salt marshes, 35% of mangroves, 30% of coral reefs and 29% of seagrasses have been either lost or are degraded worldwide (Barbier et al., 2011). The protection benefits of healthy, functioning ecosystems has significant value; for example, globally, coral reefs are estimated to protect over 100 million people from wave-induced flooding. Estimates for annual expected flood damage reduction from coral reefs exceed USD 400 million for Cuba, Indonesia, Malaysia, Mexico and the Philippines alone (Beck et al., 2018).

Sea-levels could rise by 2 metres under high-emissions

All sea-level rise values shown are with respect to mean sea-level in the 1985-2005 reference period



Source: (Lincke and Hinkel, 2018).

Changes in local sea level conditions can vary significantly from changes in global trends. For example, on the north coast of Sweden and Finland the land is currently rising faster than the sea due to post-glacial uplift. Further, local sea level is influenced by human activities, such as extraction of groundwater or oil, and changes in sediment supply from rivers due to construction. In some areas, the contribution of these activities to sea-level rise can be an order of magnitude higher than that from global climate change. For instance, in Jakarta, observed subsidence rates over the last three decades have been between 3 cm and 10 cm per year (Abidin et al., 2015).

Did you know?

Climate-induced sea-level will continue for thousands of years even if greenhouse gas concentrations are stabilised within the 21st Century. There remains considerable uncertainty over the rate and magnitude of sea-level rise, particularly at the local level and over long timeframes. This has significant practical consequences, as planning for a 0.5-metre sea-level rise is substantially different from planning for a two-metre sea-level rise, in terms of the area of land likely to be affected, and the frequency and seriousness of the impacts.

2 What are countries doing to manage rising seas?

Coastal adaptation strategies manage risks using a combination of protection, accommodation and retreat. The locally appropriate solution will be influenced by the nature of the area, the policy and institutional context, and the risks it faces.

Strategies to manage coastal risks

Objective	Measure	Benefits	Limitations
Protect (reduce the likelihood of the hazard)	Build/maintain hard defences	• Proven to be effective at preventing damage to infrastructure during extreme events • Well-established engineering guidelines and certainty under certain margins	• Displacement of beach and associated amenities • Maintenance costs once infrastructure is established • Lack of flexibility and the potential for lock-in • Risk of infrastructure failure in the future • Can create a sense of security for communities which inadvertently discourages the adoption of other risk-reduction measures
	Beach nourishment and dune restoration	• Preserves beach amenities and associated tourism activities • Is reversible and can be easily modified to the actual rate of sea-level rise	• Expensive to continue in the long term • In some cases, can be environmentally damaging to continually dredge new sand • Effectiveness is expected to decrease over time as beaches become more unstable
	Replace/reinforce shoreline protection with "living" shorelines – through planting vegetation, etc.	• Reduces negative effects of protective infrastructure (downdrift erosion) • Maintains beach habitat in enclosed areas	• Requires more planning and materials than traditional protection • Not suited for high-wave energy areas such as open beaches • Implementation and monitoring of success is not as advanced as other strategies
Accommodate (reduce vulnerability)	Change building codes and design standards to account for sea-level rise, e.g. in building elevation and foundation design	• Provides flexibility to manage future coastal inundation and flooding • More incremental change than other options	• Adds upfront development costs • Only applicable for new buildings or refurbishments • Requires a high degree of co ordination between planning and implementing agencies
	Encourage the use of property-level measures for both new and existing properties	• Flexible and easily combined with other measures • Raises household awareness of risks	• Property-level technology still underdeveloped
	Emergency management	• Mitigate loss of life and assets from coastal flooding	• Uncertainty of storm-surge predictions within early warning systems • Significant financial cost for evacuation of people
Avoidance and planned retreat (reduce exposure)	Prevent new development in areas at risk of flood or erosion through land-use regulation/zoning	• Flexible to address different conditions and needs within a community • Provides opportunity for additional access to waterfront area • Reduces potential for coastal squeeze	• Removing existing zoning rights can be a slow process that requires compensation • Only applicable for new development
	Physical relocation of people and critical assets, including removal of existing hard protection	• Protects existing and creates new intertidal habitats, which are a natural form of flood protection • Can save communities from future costs of flood protection	• Often substantial financial cost if existing property owners need to be compensated • Direct impact on those living in affected properties

Note: Non-exhaustive list.

Sources: Wilby, R.L. and R. Keenan (2012), "Adapting to flood risk under climate change", https://doi.org/10.1177/0309133312438908; Spalding, M.D. et al. (2014), "The role of ecosystems in coastal protection: Adapting to climate change and coastal hazards", http://dx.doi.org/10.1016/J.OCECOAMAN.2013.09.007; Harman, B.P. et al. (2015), "Global lessons for adapting coastal communities to protect against storm surge inundation", https://doi.org/10.2112/JCOASTRES-D-13-00095.1.

Four tools for coastal adaptation

National governments have a crucial role to play in supporting coastal adaptation by ensuring people, organisations and businesses have the correct incentives and tools to adapt, as well as removing potential distortions. Key areas for achieving this include:

	Examples
1. Providing access to information, tools and guidance	Australia's web-portal "CoastAdapt" provides tools such as inundation mapping software, local coastline morphological information, coastal climate adaptation decision-making guidance, as well as local and international case studies.
2. Ensuring that regulations and economic instruments are coherent and avoid perverse incentives	The Netherlands' National Spatial Plan is a regulatory instrument used to avoid unwanted land-use developments from taking place. It prevents new building activities in specific areas along the coast and identifies emergency water storage areas to be preserved from development along the coastline.
3. Considering climate risks when taking funding decisions	In Germany, a special instrument (Sonderrahmenplan) to speed up implementation of coastal protection due to climate change risks was established in 2009, which provides an additional combined EUR 25 million for all coastal federal states annually until 2025 (EUR 550 million total).
4. Monitoring and evaluating effectiveness of all policy interventions and adjusting accordingly	France's mid-term and end-term evaluation of their national adaptation plan allowed the government to take stock of new data regarding sea-level rise and its impact on French coasts. Key recommendations for the elaboration of a second adaptation plan included the endorsement of nature-based solutions and proposals to spatially reshape coastal areas.

Nature-based solutions for coastal protection

Nature-based solutions are increasingly being used as complements or substitutes to grey infrastructure. These defences mimic or enhance natural features, such as barrier islands, vegetated dunes, coastal wetlands, mangrove forests, and reefs. Coastal habitats reduce the vulnerability of communities through wave attenuation, sediment capture, vertical accretion, erosion reduction and the mitigation of storm surge and debris movement. A 2016 review found that coastal habitats (which included coral reefs, mangroves, salt-marshes, seagrass/kelp beds) reduce wave heights between 35% and 71% (Narayan et al.). There are some key advantages to using nature-based solutions to meet the challenge of sea-level rise:

- Ecosystems are highly dynamic in response to physical changes, and in some cases can recover and regenerate following damage.
- Nature-based solutions can deliver multiple benefits beyond coastal protection through a range of other ecosystem services. These include tourism, recreation, fish nurseries and habitat, transport, and cultural heritage and spiritual benefits.

The table below provides an overview of the approaches employed by national governments in OECD countries to address sea-level rise.

Approaches to sea-level rise management mentioned in adaptation plans

Policy lever	Information provision	Regulatory/economic instruments	Dedicated national funding	Monitoring and evaluation
Description	e.g. climate modelling, impact, vulnerability, and/or risk assessments, guidance and tools for other levels of government, business and citizens	e.g. land-use planning, building regulations, coastal protection infrastructure standards, economic incentives for risk reduction	e.g. funding of investment in risk reduction; funding for household-level protection measures	e.g. stakeholder surveys, quantitative and qualitative indicators measuring climate effects, policy process and policy outcome
Australia	●	–	–	●
Belgium	●	–	–	●
Canada	●	●	●	●
Chile	●	–	–	●
Denmark	●	●	–	–
Estonia	●	●	–	●
Finland	●	●	–	●
France	●	●	●	●
Germany	●	●	●	●
Greece	●	–	–	–
Iceland*	–	–	–	–
Ireland	●	●	–	●
Israel	●	–	–	–
Italy	●	–	–	–
Japan	●	●	–	●
Korea	●	●	–	●
Latvia	●	–	–	–
Mexico	●	●	–	●
Netherlands	●	●	●	●
New Zealand**	●	–	–	–
Norway	●	–	–	●
Poland	●	●	–	●
Portugal	●	–	–	●
Slovenia	–	–	–	●
Spain	●	●	–	●
Sweden	●	●	●	●
Turkey	●	–	–	–
United Kingdom	●	●	●	●
United States*	●	–	–	–

Notes:
● Policy instrument referred to in national adaptation strategies/plans
– Not available
* No adaptation plan in place
** Adaptation plan in development

While much can be learned from the progress in OECD countries, implementation of measures to support adaptation to sea-level rise is happening too slowly to match the challenge ahead. A lack of consideration of sea-level rise in national policies can lead to adverse outcomes, such as:

- increased reliance on hard infrastructure due to political pressure to build coastal defences as the number and value of threatened buildings increases;
- local governments and individuals pursuing policies that are rational from a local or individual perspective but create inefficiencies overall, such as granting building permits in higher-risk areas; and,
- increasing costs for the general tax base, especially if risks become uninsurable.

3 Towards an effective approach to tackling coastal risks

Drawing on lessons from detailed case studies in Canada, New Zealand, the United Kingdom and Germany, this report puts forward four principles that should be taken into consideration by national governments as they further develop and implement their adaptation responses.

Engage stakeholders early and substantively

Policy makers should engage stakeholders in the early stages of decision-making and throughout the entire decision-making process to enhance overall resilience in coastal areas, while supporting community ownership and buy-in.

While engagement is an important component of any policy change, there are specific qualities of coastal adaptation that require extra consideration:

- Sea-level rise risks are complex and difficult to understand. This is in part due to cognitive barriers around understanding risk, compounded by the fact that sea-level risks are relatively new, have associated uncertainty, and very long time scales.
- Coastal adaptation decisions, as well as sea-level rise itself, can pose a significant threat to private assets, including people's homes. It is understandable that communities may feel threatened by some adaptation measures - homes are often the most significant material and financial possession people have.

Engaging all affected stakeholders in the policy-making process is needed to ensure the development of a shared vision of risks. Once this has been achieved, it is possible to discuss and manage trade-offs across stakeholders, who can be differently affected by the economic and social impacts of sea-level rise, as well as the options to address it. Difficult decisions (e.g. limiting the approval of new properties, relocation of existing properties) should be considered, discussed and planned through a coherent, long-term approach. National governments should prioritise engagement, and provide the necessary support to other levels of government.

Stakeholder engagement in Truro, Nova Scotia

Truro, a small agricultural town in Nova Scotia, Canada, already experiences frequent severe flooding which will be exacerbated as sea-level rise continues. Raising sea walls was only modelled as effective at its most costly: when constructed as high as locally necessary (6 metres high in some areas, with commensurate design challenges given the footing width of such a dike), and when accompanied by specialised pumping (30% of priority areas protected for CAD 300 million). An alternative solution was to realign part of an existing dike and allowing privately-owned agricultural land to flood. As part of this process, a group of directly affected landowners was engaged in difficult conversations with a range of government representatives and researchers. The project proponents listened meaningfully and made adaptations to their plan, including dike placement and adding monitoring for mosquitoes. The result of this ongoing engagement was the first time affected residents in Nova Scotia voted for managed retreat: in effect, sacrificing private land for ecosystem purposes.

Plan for the future and prevent lock-in to unsustainable pathways

Policy makers need to take a long-term approach to coastal planning that actively favours flexibility.

The uncertainties associated with sea-level rise call for a dynamic, future-oriented approach to planning that explicitly deals with uncertainty. Adaptation planning must consider the impact of time on planning processes, recognising that as conditions and available knowledge change, adaptation options may also need to change (OECD, 2015).

Decisions that do not consider the future can lock-in patterns of coastal development and may be impossible to undo without prohibitive expense and effort. An illustrative example of lock-in is the construction of protective infrastructure, which can create a cycle of coastal development and increased protection, termed "the levee effect". Once structural protection is built, the perception of increased safety can lead to further development in the flood plain, which can have the perverse impact of increasing vulnerability in the longer term (OECD, 2014b). If those defences then fail, the results can be catastrophic.

The specific characteristics of sea-level rise increases the value of robustness (the ability to perform across a range of conditions) and flexibility (the capacity to adjust with changing conditions). Placing value on flexibility and robustness can preference innovative measures such as nature-based solutions, which can be easily modified to the actual rate of sea-level rise. Accommodation measures, such as changing building design, also present a more flexible approach that leaves further options available in the future.

The New Zealand case study provides an example of dynamic adaptive pathways planning. The pathways approach involves testing different adaptation measures against a wide range of sea-level rise projections, which informs the development of alternate policy pathways that are robust and flexible.

Align responsibilities, resources and incentives

Policy makers need to understand and address the incentives and constraints faced by relevant actors.

The way coastal incentives, capacity and roles are allocated influence the way each individual actor decides about whether or not to invest in resilience. Policy misalignments and other barriers can hinder the implementation of cost-effective responses or lead to choices that prove maladaptive over time. Existing institutional arrangements may undermine effective and efficient adaptation, by distorting market signals or providing perverse incentives.

If an individual, institution or business is aware of owning or sharing a risk, but has little reward or incentive attached to managing responsibilities, it can result in increasing risk overall. For example, property developers often do not bear future costs from current development,

Key actor and role	Drivers of behaviour	Example of misaligned incentives
	Private Actors	
Individuals/property owners • Prospective homeowners make decisions about the location and material of their home. • Existing homeowners can invest in property-level risk reduction measures, as well as purchase insurance (where available). **Property developers** • Make decisions about the construction of new housing and investing in maintaining existing housing stock.	• Motivated to reduce the cost of potential damages and preserve the value of their asset. • Face the direct financial costs and intangible consequences (such as mental health impacts) of an extreme event. • Incentive to preserve property value and reduce additional costs. • Coastal real estate usually has high value due proximity to amenities and water view.	If governments assist homeowners in post-disaster recovery and reconstruction, regardless of their insurance take-up prior to the shock, it undermines individual homeowner incentives to invest in ex-ante risk reduction or transfer measures. If property prices/ insurance premiums do not reflect risk, and coastal property is highly valued, there will be a strong incentive to continue to invest and build in high risk coastal areas.
	Public Actors	
Local governments • Often have responsibility and jurisdiction for coastal adaptation through land use planning, emergency management, and educating the community.	• Benefit from development through the generation of local tax revenues. • Can be directly exposed to financial risks from sea-level rise-induced hazards through changes in property values. • Can bear the costs of relief and recovery, reconstruction of public assets, payments as compensation to individuals and businesses (often first in line for providing support).	Local governments may permit construction in risk prone areas if they gain from increased economic activity and tax revenues, while the costs/portion of costs are borne by other levels of government.
National/State governments • Role in ensuring the relevant actors have adequate incentives and tools to adapt, including the provision of climate risk information, and provision of resources for investments in risk reduction.	• Can bear the costs of relief and recovery, reconstruction of public assets, payments as compensation to individuals, business and/or sub-national levels of government, and public insurance/(re)insurance schemes that provide coverage for damages and losses.	Political cycles can discourage long-term investments in sea-level rise adaptation, as their benefits may be less visible in the short run or not visible at all within the period of a government's mandate.

Source: Adapted from OECD (2014a), Boosting Resilience through Innovative Risk Governance, OECD Reviews of Risk Management Policies, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264209114-en.

and as a result lobby for coastal land releases. In addition, political economy challenges arise from entrenched policies and institutional arrangements (e.g. property and land rights, existing public infrastructure, stakeholder expectations). Funding arrangements, and related planning and regulatory frameworks, must therefore be well coordinated and designed to minimise moral hazard.

Explicitly consider distributional and equity implications of policies

Policy makers must explicitly address the distributional and equity implications of policies that address coastal risks.

Changes to the allocation of risks and responsibilities relating to sea-level rise will have significant distributional impacts. Some adaptation measures may result in significant costs for property owners in areas of risk. These costs can include:

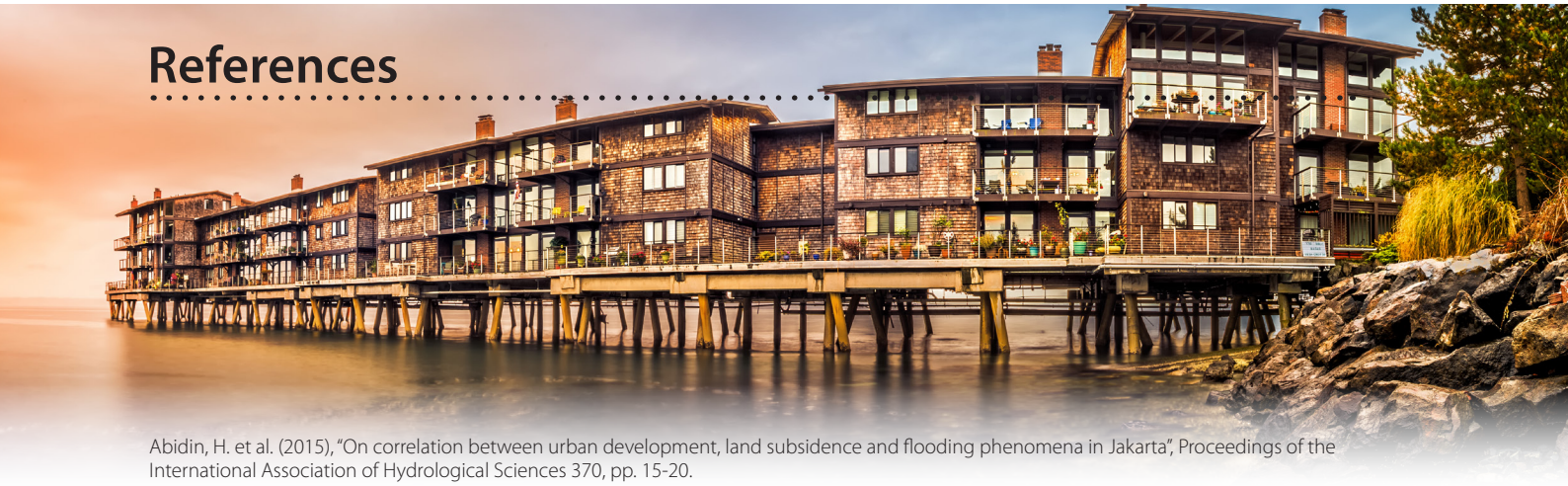
- The requirement to allow their land to be flooded periodically.
- Being prohibited from building certain protective structures on their land.
- Higher insurance premiums.

Given potential costs, the distributional impacts of policy reforms need to be addressed in the process of implementing reforms.

An important first step for policy makers is undertaking detailed risk assessments that account for socioeconomic vulnerability and associated adaptive capacity of those in the path of the hazards, as well as the hazards themselves. This can inform future policy design. In some cases, compensation schemes may be required to relieve at least some of the economic burden of being located in a high-risk area.

Conclusion

There is robust evidence and a compelling case for further action to address the consequences of sea-level rise. While not all coastal risks can be avoided, well-prepared coastal communities will be better able to adjust to new conditions, at lower cost, and rapidly bounce back from disasters when they occur.



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Responding to Rising Seas
OECD Country Approaches to Tackling Coastal Risks

There is an urgent need to ensure that coastal areas are adapting to the impacts of climate change. Risks in these areas are projected to increase because of rising sea levels and development pressures. This report reviews how OECD countries can use their national adaptation planning processes to respond to this challenge. Specifically, the report examines how countries approach shared costs and responsibilities for coastal risk management and how this encourages or hinders risk-reduction behaviour by households, businesses and different levels of government. The report outlines policy tools that national governments can use to encourage an efficient, effective and equitable response to ongoing coastal change. It is informed by new analysis on the future costs of sea-level rise, and the main findings from four case studies (Canada, Germany, New Zealand and the United Kingdom).

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OECD, 2019, *Responding to Rising Seas: OECD Country Approaches to Tackling Coastal Risks*, OECD Publishing, Paris, https://doi.org/10.1787/9789264312487-en.

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