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Author

Bisaro, A, de Bel, M, Hinkel, J, Kok, S, Stojanovic, T, Ware, D

Published

2020

Journal Title

Environmental Science and Policy

Version

Accepted Manuscript (AM)

DOI

[10.1016/j.envsci.2020.05.018](https://doi.org/10.1016/j.envsci.2020.05.018)

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Title: Multilevel governance of coastal flood risk reduction: a public finance perspective

Article type: Research article

Authors:

Alexander Bisaro^{1*}, Mark de Bel², Jochen Hinkel¹, Sien Kok², Tim Stojanovic³, Daniel Ware⁴

* Corresponding author: sandy.bisaro@globalclimateforum.org, Neue Promenade 6, 10178 Berlin, Germany

¹ Global Climate Forum e.V., Germany

² Deltares, Netherlands

³ University of St. Andrew's, United Kingdom

⁴ Griffiths University, Australia

Abstract:

Coastal flood risk reduction (CFRR) presents a significant public funding challenge, due to its high upfront costs and long-term benefits, and this challenge will increase with future sea-level rise. The funding challenge necessarily involves multiple levels of government, due to the regional nature of CFRR public goods involved. Yet there has been little research comparing such multilevel arrangements across countries, and in particular exploring the performance of public funding arrangements for providing coastal flood risk reduction. We address this gap, applying fiscal federalism to develop a multilevel governance analysis of public decision-making and fiscal authorities for CFRR in the Netherlands, Germany, the UK and Australia. For each country, we locate key decision-making and fiscal authorities in multilevel governance arrangements, and analyse their alignment with the benefits of CFRR measures (spillovers). We find diverse coastal flood risk governance arrangements ranging from highly centralised (NL), mixed arrangements, involving regional centralisation (Germany) or partial devolvement (UK), to full decentralisation (AUS). Further, we find that in accordance with fiscal federalism, multilevel coastal flood risk governance arrangements are generally reflective of the distribution of the benefits across different levels of government, with some exceptions (Germany and UK). Finally, exploring the outlook of current arrangements under sea-level rise, we find that major fiscal redistributions may be put under pressure by rising costs likely under SLR and future coastal development. This is particularly the case for those systems which operate under hazard-based, as opposed to risk-based, coastal protection policies. Further, we find that both fully and moderately decentralised arrangements may require greater central support for alternative measures, such as retreat, in light of growing financial burdens on local governments.

1. Introduction

Coastal flooding is a significant risk around the world, and will increase with future sea-level rise and coastal development (IPCC, 2019). Coastal flood risk reduction (CFRR) entails the physical measures such as seawalls, dikes and tidal barrages necessary to reduce the impact of coastal floods. CFRR requires substantial investment. Current estimates of investments needed globally to raise current coastal protection up to standards of the most flood risk intolerant countries are up to US\$4 trillion (Nicholls et al. 2019). Moreover, investment needs will increase with socio-economic development and sea-level rise (SLR), and could lead to up to \$70 billion in annual protection costs globally by 2100 (Hinkel et al., 2014).

Meeting these needs is largely a public funding challenge. Governments often have statutory requirements to provide coastal protection, and are otherwise either explicit or implicit insurers of last resort (Jongman et al., 2014). Governments thus have a requirement or incentive to invest in CFRR and reduce their contingent liabilities. This a challenge for governments because CFRR measures generally have high up-front investments costs that produce benefits for the public budget only over the medium to long-term when damages from expected flooding are avoided. Governments can avail of various fiscal instruments to fund such measures, including taxation (Peterson, 2018), public debt instruments, e.g. ‘green bonds’ (Keenan, 2018), as well as cost sharing arrangements with the private sector (Bisaro et al., 2019; Pauw et al., 2015).

The funding challenge necessarily involves multiple levels of government, as CFRR generally involves (hard or soft) infrastructure with long time horizons, involving spillovers typical of public goods (Bisaro and Hinkel, 2016). Such spillovers, i.e. non-excludable benefits (avoided damage) from coastal flood risk reduction measures, implicate multiple levels of government because they often span multiple scales and jurisdictions beyond the immediate physical location where a flood occurs (Woodruff et al. 2020). An emerging literature has begun to explore this challenge finding that distributional conflicts that arise across different levels of government, e.g. over who pays for a given measure (Storbjörk and Hedrén, 2011) and between jurisdictions, e.g. over who receives funding for measures (Adger et al., 2016; Osberghaus et al., 2010), hinder public investments. Work in the US has largely focussed on barriers at the local level, exploring the acceptability and effectiveness of differential coastal property taxes through agent-based modelling (Mullin et al., 2018), the influence of risk awareness and political preferences on support for local government finance instruments (Merrill et al., 2018), and finding systematic barriers to funding adaptation arising from a lack of capacity and misaligned performance incentives for local officials (Moser et al., 2019).

Yet, while public funding of CFRR is increasingly salient, gaps in the literature remain. Studies of flood risk governance have taken up issues of how power and scale influence governance arrangements and policy design (Bubeck et al., 2017; Penning-Rowsell and Johnson, 2015), however these generally do not include detailed analysis of financial dimensions. Further, the heavy focus on barriers to public funding, particularly in the coastal adaptation literature, generally under-emphasises questions of explaining governance performance (Biesbroek et al., 2015). Such questions are important and have been developed in the environmental governance literature more broadly, for instance, through analysing the ‘fit’ of multilevel governance arrangements to properties of coastal systems (Young, 2002).

This paper addresses these gaps, analysing multilevel governance arrangements for CFRR with a focus on public funding arrangements. In particular, we apply approaches from multilevel governance and fiscal federalism, which provide arguments relating multilevel governance arrangements to performance based on aligning authority with characteristics of public goods, e.g. spillovers (Oates, 2005, 1972). Fiscal federalism is a subfield of public finance, that addresses

financial relationships between levels of government within multilevel governance systems (Oates, 1999). Such approaches can shed light on the suitability of existing governance arrangements for meeting the CFRR funding challenge, as CFRR is a public good with potential regional and national spillovers. Indeed, such political science approaches, while highly relevant to adaptation, have yet to be fully exploited (Javeline, 2014).

The paper thus addresses the following research questions:

1. Where is public planning and fiscal authority regarding CFRR located in governance arrangements, and how is it distributed across governance levels?
2. Are the observed governance arrangements for CFRR politically and fiscally well-aligned?

To operationalise these research questions, we develop the concept of “well-aligned” following prescriptions of the fiscal federalism literature, which are explored in Section 2.2. To address these questions, we translate multilevel governance and fiscal federalism approaches to the CFRR context, and compare arrangements in 4 countries (Netherlands, Germany, UK and Australia). Our comparative research design allows us, first, to describe current coastal flood risk governance arrangements in countries relatively advanced on this issue (Danielson et al., 2019). This explorative research objective is important in its own right, due to the lack of attention to funding arrangements noted in the literature. Second, the research design enables us to address performance questions in a normative sense, rather than positive sense, which is important given the context dependent nature of CFRR goals (see Section 2). Finally, we reflect on the outlook for these arrangements under future SLR, given that SLR will increase the costs of CFRR.

2. Analytical framework

2.1. Multilevel governance and coastal flood risk governance research

Multilevel governance (MLG) research emerged to analyse the shift from hierarchical modes of governance towards shared authority resulting from European Union reforms in the late 1980s (Tortola, 2017). Political science-oriented MLG scholarship thus has a strong descriptive element, aimed at documenting change and stability in governance arrangements and associated governance modes. For example, MLG modes have been characterised along the dimensions of political and administrative decentralisation (Kuhlmann and Wayenberg, 2016), decentralised and deconcentrated regional authority (Hooghe et al., 2016), or hierarchical, market, and network governance (Tenbenschel, 2005). In the climate domain, recent work has identified the emergence of polycentric governance modes (Jordan et al., 2015).

MLG generally views authority as multidimensional, comprising a number of core public planning and fiscal dimensions (Verhoest et al., 2004). Numerous authors use somewhat differing terminologies to characterise authority, and associated MLG governance arrangements (Feeley and Kesari, 2017; Kuhlmann and Wayenberg, 2016; Peters, 2014). We follow Hooghe et al. (2016) who develop a set of dimensions to characterise regional authority. While Hooghe et al. (2016) focus on regional authorities, we focus on multiple levels of government, and therefore we have slightly adapted the categories. In particular, we focus on the dimensions of 'shared rule', which describe how authority is shared across different levels of government, because these are pertinent to our research questions. 'Shared rule' dimensions include three decision-making authorities of 'constitutional reform', 'law making', and 'executive' as well as a 'fiscal control' dimension. We translate these general public authorities for the more specific issue of coastal flood risk reduction in Table 1, based on our own analysis, and drawing on the coastal governance literature. For example, for the dimension “constitutional reform”, in a coastal setting, we interpret this to refer to authority over long-term strategic goal setting for CFRR. Strategic goal setting is constitutional in that it establishes enabling and constraining conditions in which law-making and project design for

CFRR take place. Here, we acknowledge that, in contrast to the situation for the wider governance setting, such authority in coastal settings is often not explicitly defined. For example, in Schleswig-Holstein, Germany, the strategic goal to protect the existing coastline is implicitly set through the State Water Law (see Section 4.1 below). Typical strategic goals for coastal risk, i.e. protection, accommodation, retreat or avoidance, have been identified in the coastal governance literature (Klein et al. 2001).

Further, we point out that our approach analyses only formal rules, as opposed to informal rules, which gives rise to some caveats. First, we assume that formal authorities at higher levels of governance are not contradicted by local rules or practice. Thus, for the dimension “Set CFRR rules”, we focus on the level at which binding rules on flood safety are set, e.g. on protection levels, set-back zones, etc., and assume that such binding rules are not contradicted by rules, or practice, at lower levels of government. If no binding rules are set at national or state levels, we assume that CFRR rules are set at the local level.

Second, our focus on only formal rules means that we do not analyse implementation capacity, for example, of state or local agencies either in undertaking CFRR projects or collecting general tax revenues (e.g. from property taxes or building permits). Implementation capacity is an important dimension of governance, as are the incentives provided to government at different levels by these general revenue instruments. However, as mentioned above, this paper addresses a gap in the literature on public finance arrangements for CFRR, and thus we have delimited the scope in order to keep our comparative analysis tractable. Our approach thus provides an entry point for characterising authority in multilevel governance arrangements for CFRR, and the alignment of formal dimensions of decision-making and fiscal authority. Future research on important complementary questions on the role of informal institutions and implementation capacity in multilevel governance arrangements for CFRR is desirable and can build on the approach developed here.

Dimension of authority	Meaning	Translation for coastal flood and erosion risk management	Meaning
Constitutional reform	Which levels of government (co-)determine constitutional change	Set strategic goal	Which levels of government (co-)determine the medium to long-term goal for coastal risk management. Authority for such goal setting may be implicit or explicitly defined, e.g. through establishment of a statutory body for goal setting. Typical goals are: protect, accommodate, retreat, avoid. (Klein et al 2001)
Law making	Which levels of government (co-)determine national law	Set coastal flood risk reduction rules	Which levels of government (co-)determine rules for coastal flood risk reduction. For example, CFRR rules may be set by exclusively national (or regional) legislative bodies. Alternatively, they may be set by committees with members from several levels of government. Typical types of rules are: flood safety norms, funding rules, planning regulations.
Executive	Which levels of government (co-)determine policy in intergovernmental organisations	Design measure	Which levels of government (co-)determine the design of individual CFRR measures. Project design may be carried out by national level implementing agencies, or by designated local authorities. It may also be carried out by entities with members from several levels of government.
Fiscal control	Which levels of government (co-)determine tax distribution	Fiscal control	Which levels of government (co-)determine the total budget for CFRR, and dedicated tax revenues, i.e tax base and rates. General revenue taxes, and dedicated CFRR levies, may be set by national, regional or local governments depending on tax legislation.

Table 1. Translating dimensions of public authority (Hooghe et al. 2016) for coastal flood risk reduction.

2.2. Multilevel governance performance

MLG scholarship also goes beyond description, and addresses questions of governance performance in regard to the efficiency and effectiveness of public good provisioning. Such approaches integrate public finance and administration literatures (Peters, 2014), and are rooted in the idea that shared governance arrangements distribute authority and responsibility across multiple levels, and thus influence the incentives for provisioning of public goods by actors at different levels (Peters and Pierre, 2005).

Approaches that emphasise financial dimensions, the focus of this paper, are those of fiscal federalism, which underline that MLG arrangements should account for heterogeneous local preferences, and enable participation and local accountability in order to enable efficient and effective public good provisioning (Kuhlmann and Wayenberg, 2016). At its core, the fiscal federalism literature provides three principles around which to organise multilevel governance performance (Peterson, 2018). First, Oates' (1972) 'decentralisation principle' states that because of heterogeneous local preferences and a central government's difficulty in ascertaining these, public good provisioning should be devolved to the lowest level possible. Second, the 'equivalency principle' states that the level of government responsible for a decision should overlap with the jurisdiction or constituency benefiting from it (Olson, 1969). Third, the 'benefits model' principle of public finance provides an overlapping fiscal perspective, stating that beneficiaries of public good should pay for it, whenever possible (Kitchen and Slack, 2006). Taken together, these principles imply that public good provisioning should be devolved to the local level, except where the regional or national nature of public goods mediate against it.

For CFRR, the public good provided can have regional or national characteristics due to the direct and indirect spillovers of CFRR measures. Direct spillovers occur when floodplains are large,

densely populated or interconnected. This is because, in such conditions, dike building at one location may reduce flooding in adjacent communities, affecting large numbers of people and assets (Mostert, 2017). Indirect spillovers from CFRR occur when economic impacts of coastal flooding are manifested in regions and sectors that are not directly physical impacted by a flooding event. For example, a coastal disaster may disrupt supply-chains in a national economy, which thus create negative indirect spillovers (Lenzen et al., 2019). While detailed assessment of both types of spillovers, e.g. through hydrological and macro-economic modelling, is beyond the scope of this paper, we provide a rough indicator for each type of spillover below (Section 3).

Taking these two aspects together, that is, the principles of decentralisation, equivalency and 'benefits model' provided by the fiscal federalism literature, and the concept of direct and indirect spillovers of CFRR measures, it is possible to derive some prescriptions for coastal flood risk reduction MLG performance. In other words, these prescriptions define "well-aligned" multilevel governance arrangements with respect to the spillovers of CFRR measures they govern. First, when both direct and indirect spillovers from CFRR are small, fully decentralised governance are "well-aligned" and promote governance performance. Spillovers are small, when for example the coastal floodplain is sparsely populated with few assets, and these assets in the coastal floodplain assets make up a small proportion of national GDP, e.g. less than 5% (see Table 6 for measures of direct and indirect spillovers). In such cases, local communities are the only beneficiaries of a CFRR measure, and they should be responsible for deciding upon and funding the measure, both for economic efficiency (Oates 2005) and democratic accountability reasons (Kuhlmann and Wayenberg, 2016). Second, in contrast, when spillovers are large, then centralised decision-making and funding of CFRR, involving actors beyond the immediate geographic scope of the measure, can be "well-aligned" and promote performance. In this case, authority in MLG arrangement should as far as possible be aligned with the geographic scale at which spillovers occur.

Based on these prescriptions for the 'alignment' of governance arrangements and coastal flood risk, we develop our comparative analysis of MLG arrangements and their performance. We note that our analysis of governance performance is normative in the sense that it assesses whether MLG arrangements are 'aligned' with prescriptions of fiscal federalism. In contrast, a positive approach to assessing MLG performance would take MLG arrangement outputs (e.g. policies, plans, or investment levels) or outcomes (e.g. risk reduction) as a dependent variable, and evaluate these against a benchmark, e.g. of "good" investment or safety levels (Young, 2011). However, for such positive approach establishing benchmarks to evaluating CFRR outcomes is highly context dependent, and depends on a number of further socio-economic variables, such as, values, risk adversity, and development goals (Dupuis and Biesbroek, 2013). As such, comparing such indicators across socio-economic contexts, i.e. different countries, may not be meaningful. Therefore, we pursue the normative approach based on the prescriptions of fiscal federalism assessing the 'alignment' of the MLG to coastal flood risk spillovers presented in Section 5.

3. Materials and methods

3.1. Case selection and data collection

Our research questions are addressed by examining governance and finance arrangements in 4 developed countries with significant exposure to coastal flood risk: the Netherlands, United Kingdom, Germany, and Australia. Each are advanced economies with long histories of coastal flood risk management interventions. They however differ in their CFRR governance arrangements, thus provide a diverse sample of CFRR public funding arrangements, and geography of coastal flood risk. (See supplementary materials for more details on the each country and the relevant policies for CFRR).

Our cases encompass two unitary systems (United Kingdom (England) and Netherlands), and two federal systems (Germany and Australia). Though the differences between the two types of system are decreasing (Hooghe et al., 2016), federal systems generally involve an additional government level, i.e. the federal state, compared to unitary systems (Biesbroek et al., 2018). Our analysis of federal systems thus focuses on one federal state within the relevant country. Data was collected through an extensive desk review of laws and policy documents and consultations with experts in each of the four countries (See Supplementary materials).

3.2. Direct and indirect spillovers in the cases

Table 2 summarises key exposure characteristics across the 4 countries (see Supplementary materials for more detailed description). Measures of *direct spillovers* from coastal flooding are provided by exposed population, i.e. population in the 1-100 year floodplain, and the exposed population per km of coastline. We note that these are only rough indicators, and should be treated with caution, as both the coastal length indicator and estimates of population exposed to coastal flooding are subject to large uncertainties due to well-known weaknesses in the underlying data sets (Neumann et al., 2015; Vafeidis et al., 2008). Direct spillovers are largest in the Netherlands, and smallest in Queensland with its relatively sparsely populated coast (Table 2).

		Netherlands	England (United Kingdom)	Schleswig- Holstein (Germany)	Queensland (Australia)
	Coastal length (km)	366	4273	1093	6973
<i>Measures of direct spillovers</i>	Pop. 1-100 yr coastal floodplain*	3,616,000	1,904,000	111,000	121,000
	% of state pop.	n/a	n/a	3.85%	2.4%
	% of national pop.	21.30%	3.20%	0.13%	0.49%
	Exposed population per km of coastline	9880	446	736	47
<i>Measures of indirect spillovers</i>	Assets 1-100 yr coastal floodplain (US\$ billion)**	551	222	11	16
	% of national GDP	60.4%	7.9%	0.3%	1.1%

* Values from Hinkel et al. (2014).

** Derived from coastal population in the 1-100 coastal floodplain, national GDP/capita, and assets-GDP relationship from Hallegatte et al. (2013).

Table 2. Coastal population and exposure in the 4 countries.

A measure of *indirect spillovers* is provided by exposed population as a share of either state or national population, and exposed assets in relation to national GDP. This is also only an approximate measure, and we note that more comprehensive assessment of indirect spillovers, e.g. through macro-economic modelling, is beyond the scope of this paper. Indirect spillovers are very high for the Netherlands (21.3% of national population exposed, and exposed assets being 60% of GDP) and significantly lower for all other countries, with Schleswig-Holstein exhibiting least indirect spillovers.

In the next Section, we describe the key CFRR governance arrangements, before analysing their alignment with the spillovers described here in Section 5.

4. Characterising multilevel coastal flood risk governance

4.1. Federal State of Schleswig-Holstein, Germany

The German constitution defines coastal protection as a “joint task” for all citizens (§ 91a), and public CFRR authorities are thus distributed between three levels of government, Federal (*Bund*), State (*Land*), and Local (*Kommune*) by Federal and State laws. This is characteristic of German federalism more broadly, which involves significant shared-rule between Federal and State levels across many policy areas, with state law often ratified by the national senate (*Bundes Rat*) (Austin et al. 2018). A defining feature of Schleswig-Holstein (SH) coastal risk governance is a dual-system in which authorities over State Dikes and Local Dikes¹ are split between the State and the Local Authorities respectively (see Figure 1).

Authority to set strategic goals is held at the State level under the SH Water Act (LWG, 2008). The Act makes the State responsible for the construction and maintenance of dikes that protect the “general welfare” (LWG, 2008, §63 (1)), establishing an implicit legal basis for a “protection” strategy. The Act also establishes the dual State and Local Dike system. Outside areas protected in the interest of “general welfare” – nearly all of the North Sea coast, and short sections of the Baltic Sea coast – local authorities are responsible.

Authority to set CFRR rules is located at the State level for State Dikes. Federal law requires States to develop Coastal Protection Master Plans and Integrated Coastal Zone Management (ICZM) Plans, and thus decisions on dike design heights and coastal land use are made by the State through the Master Planning process in consultation with multiple stakeholders. In line with the EU Flood Directive, the 2012 Master Plan introduced a uniform flood safety standard for State Dikes, and included consideration of 0.5m to 1.4m SLR this century. Dike design heights were determined using statistical modelling of the 1-in-200-year event plus an allowance of 0.5 m for SLR, or the highest observed water levels. Further, outer State Dike crests are to be widened from 2.5m to 5.0m during reinforcement to accommodate SLR uncertainty, as future dike heightening is cheaper with wider dike crests in place.

Authority for designing actual measures differs for State and Local Dikes. For State Dikes, the State exercises this authority through the Master Plan. For Local Dikes, authority is held by local authorities, who are not bound by the Master Plan standards.

Regarding fiscal control, authority is shared between the Federal Government and 16 States, who together fund the Joint Task for the Improvement of Agricultural Structures and Coastal Protection (GAK), the principal federal coastal protection funding instrument. The overall GAK budget, and project approval, is agreed through majority voting of the 16 States and Federal Government (with the Federal Government vote counting for 16). The GAK reimburses 70% of investment costs for coastal protection measures, not otherwise covered by EU funds. The State pays the remaining 30% of investment costs, and 100% of maintenance. For Regional Dikes, municipalities or WSAs may receive 90% of investment costs from the State, and need to cover the remaining 10% themselves.

Since 2001, total spending on CFRR in SH is €600 million, with roughly half coming from the State, 37% from the federal level, and 13% from the EU (MELUR, 2012). A Special Instrument (*Sonderrahmenplan*) within the GAK was established in 2009 to speed up implementation of coastal protection due to climate change risks, providing an additional €25 million annually for all coastal States until 2025 (€550 million total) (BMEL, 2013). Schleswig-Holstein received ca. €8

¹ These are called “Regional Dikes” in the Schleswig-Holstein legal and policy documents. However, for consistency, we use instead “Local Dikes” to indicate they are implemented at a local, as opposed to a regional level of government.

million annually from 2015 and 2017 through this instrument (BMEL, 2018).

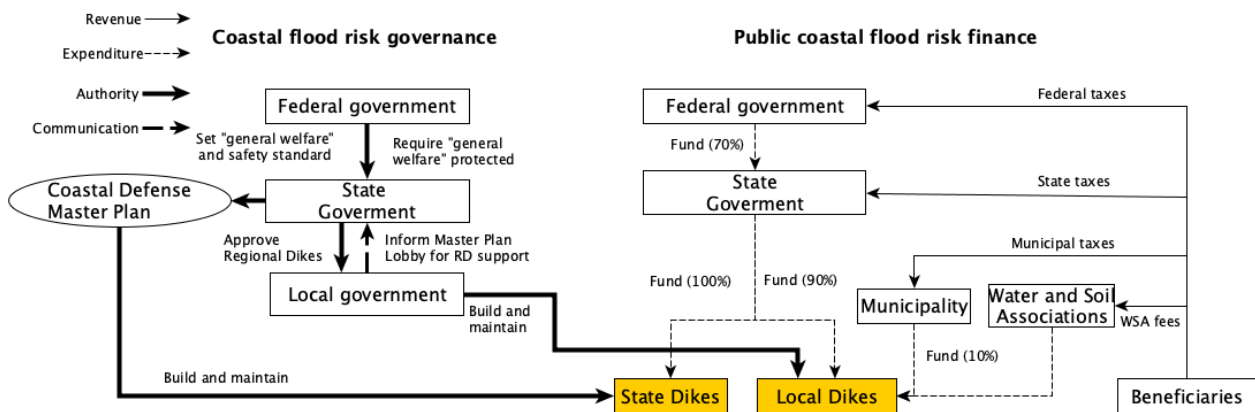


Figure 1. Coastal flood risk governance and public finance arrangements in Schleswig-Holstein, Germany. The governance arrangements are described in terms of “Authority” along the 4 dimension of authority described above; and “communication” between different government levels. Revenues and expenditures describe the public finance flows between different government levels. Beneficiaries refer to beneficiaries of CFRR measures, i.e. coastal populations and asset owners.

4.2. The Netherlands

The National Water Law (2010) delineates public responsibilities for CFRR to the national government through the Ministry of Infrastructure and Water (MIW) and its implementing agency Rijkswaterstaat (RWS), and the local Water Authorities (see Figure 2). Further, the 2012 Delta Law (2012) established a parliament-appointed Delta Commissioner to coordinate national policy on flood risk management and fresh water supply. This is consistent with the broader character of the Dutch governance system which is characterised as corporatist, concentrating authority with national government though incorporating various (non)state actors interests through consensus-seeking (Biesbroeck et al. 2018).

Authority to set strategic goals is held at the national level. The Water Law establishes ownership of dikes with the national government, and requires these maintained to flood safety standards determined by national law. Implicitly the strategy is to protect, as the scope for alternative strategies, e.g. retreat, is limited by geography. While the recent ‘Room for the River’ programme has involved ‘retreating’ by widening rivers in some areas, these measures do not reduce overall development in the coastal floodplain.

Authority to set CFRR rules is at the national level, as the parliamentary legislates flood safety. In January 2017, a new law regarding flood protection standards was adopted, setting out a maximum level of risk in terms of human lives and economic damages (Van der Most et al., 2014). The new standard leads to protection levels of 1:300 – 1:100,000 years for various defence sections as the risk-based standard implies that potential flood impact in a given area leads to a higher protection level in that area. This represents a shift from the previous “security-based” to a “risk-based” approach. However, the minimum risk-threshold is very high and thus, in general, flood protection levels have increased, necessitating elaborate reinforcement works. The Delta Commissioner defines priorities for investment to ensure primary defences comply with the new standards by 2050.

Authority for designing actual measures is also held at the national level. CFRR measures must meet Flood Safety Law and Delta Programme requirements, though experimentation with e.g. Nature-based Solutions, such as the Sand Engine or the Room for River program, is underway (Stive et al., 2013). Implementation of dike reinforcement is carried out by the High Water Protection Programme (HWBP), a joint implementing organization from RWS/MIW and the Water Authorities. The Delta Commission, however, retains overall responsibility for coordinating activities of RWS and the Water Authorities, regularly reviewing whether current implementation programs are sufficient, e.g. to account for sea-level rise, land subsidence or economic development.

Regarding fiscal control, authority is at the national level, which determines the Dike Account budget, the principal CFRR funding instrument. Dike reinforcement is funded 50% by the Delta Programme, and 50% by regional Water Authorities, whose individual contributions are determined by national regulations and based on number of inhabitants and property values. Historically, WAs had greater control over taxation in their jurisdictions. However, following the 1953 floods, financing responsibilities for coastal protection were largely shifted to the national level, and reforms in the subsequent decades further equalised taxation levels between different WAs (Mostert, 2017).

The Dike Account funds the long horizon HWBP implementation programme, funding large investments to 90%. The remaining 10% is funded by the Water Authority in whose jurisdiction the project is implemented. The current dike reinforcement phase runs until 2030, with a committed national budget of €367 million a year (total budget €3.8 billion).

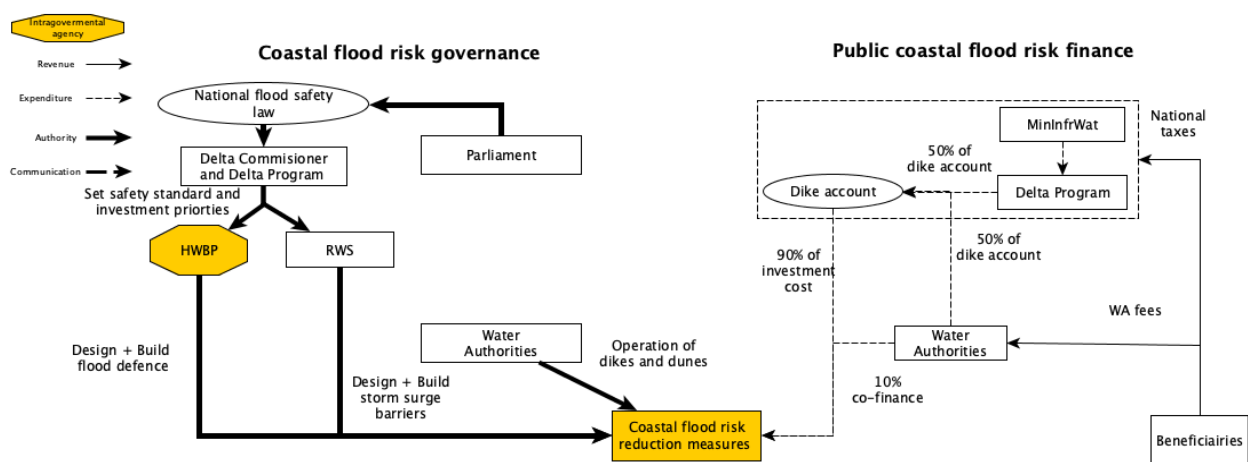


Figure 2. Coastal flood risk governance and public finance arrangements in the Netherlands

4.3. England, United Kingdom

CFRR governance in England has developed from a fragmented system with little national co-ordination before the 1990s, to a more integrated but complex system, addressing a range of coastal hazards. The *UK Coast Protection Act 1949* sets out the legal responsibilities for CFRR, while the *2010 Flood and Water Management Act 2010* develops a more integrated approach to all sources of flooding, following serious riverine flooding in 2007 (see Figure 3). In terms of law making and fiscal authority, CFRR governance is generally consistent with the broader centralised character of the UK unitary governance system.

Authority to set strategic goals is explicitly shared between national and local levels, focusing on risk minimisation rather than assuming the coast will be defended, through Shoreline Management

Plans (SMP) (DEFRA, 2006). *Coastal Defence Groups* comprise multiple local coast protection authorities working with the Environment Agency to develop SMPs with input from other stakeholder, such as conservation agencies, port authorities, or water companies. SMP are strategic planning documents for sections of coast, ‘coastal process units’, defined based on sediment circulation patterns. The 22 SMPs (including Wales) each establish one of four strategic goals: ‘no active intervention’ ‘hold the line’ ‘management realignment’ or ‘advance the line’, but do not stipulate individual flood defence schemes, which are usually the subject of more detailed assessments.

Authority to set CFRR rules is at the national level, as the Department of Environment Food and Rural Affairs (DEFRA) sets national guidance on coastal risk management and, importantly, financing rules for CFRR. In 2011, DEFRA introduced the key funding instrument, ‘Flood and Coastal Erosion Resilience Partnership Funding’ or Partnership Funding (DEFRA, 2011).

Authority for designing actual measures is held at the local level, as Coastal Protection Authorities generally have operational responsibility to undertake engineering and maintenance of CFRR schemes. While the Environment Agency also has operational responsibilities in some locations, this is due to the historical idiosyncrasies of who owns the shorefront or flood defence asset in a specific location. These local responsibilities are consistent with the ‘devolved’ authority approach of Partnership Funding, which stipulates only the rules under which measures will receive funding, and does not further constrain local authorities' design of measures.

Fiscal control is held at the national level, as the CFRR budget is largely funded through several national instruments. The most significant of these is Partnership Funding, which is dispersed based on a weighted measure of a scheme's overall benefits; household flood risk reduction, with a weighting towards deprived households; reduction of coastal erosion risk; and environmental outcomes, e.g. for Habitats or Water Framework Directive commitments. Schemes that achieve sufficient scores are fully funded, though the bar is high, as recent fully supported schemes had a benefit-cost ratio greater than 8 (CCC, 2018). Lower scoring schemes require additional funding, e.g. from Environment Agency levies, Local Authority funds, or private sources.

The annual national government budget for all flood risk management was £692m for 2017-18 (DEFRA, 2018). The major source of CFRR funding is the DEFRA budget, which disburses funds to the Environment Agency and Local Authorities. Other funding sources include: i) a levy on local authorities, which accounted for roughly 3-5% annual total funding 2006-2015; ii) levies from Internal Drainage Boards, (iii) local authority core funds (iv) private finance and other sources such as lottery, charities or community groups. Partnership Funding aims to increasing sharing of costs between the national and local levels, with a target of 15% local funding in the 2015-2021 programme, up from 6-7% in 2006-2015 (DEFRA, 2018). We note that new funding rules for CFRR have been announced by the central government in April 2020, and will come into effect in 2021 with the aim of increasing absolute amount of central government funding for CFRR.

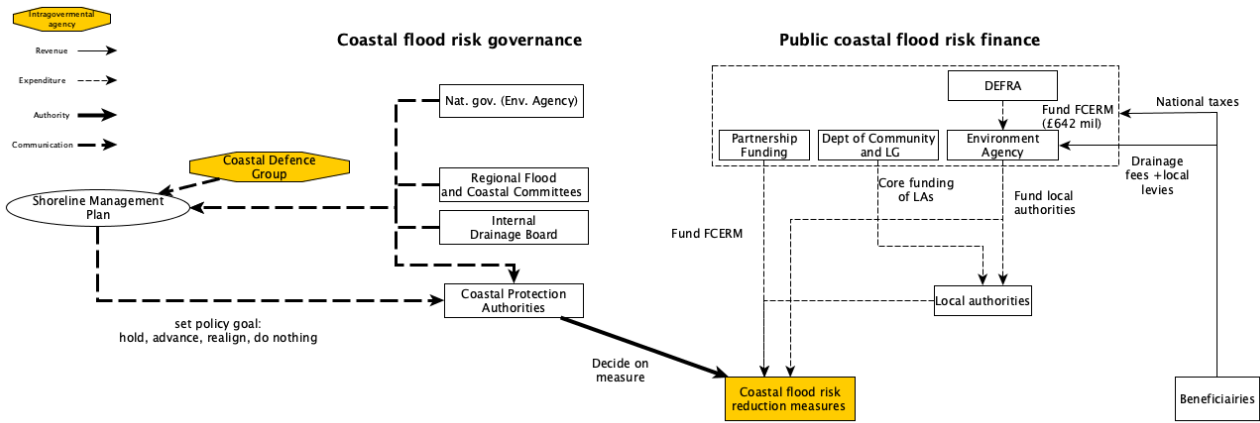


Figure 3. Coastal flood risk governance and public finance arrangements in England, UK.

4.4. Queensland, Australia

Distribution of powers between Australia's Federal and State Governments is based on authorities specifically granted to the Federal Government by the States through the Constitution. As governance of natural hazards was not addressed in Constitution, it remains a responsibility of State governments (Britton and Wettenhall, 1990). In Queensland, the Local Government Act establishes a third level of government relevant to CFRR (see Figure 4). This is consistent with Australian federalism more broadly in which authority in several domains is devolved to regional governments, while the national government controls taxation revenue significantly higher than its expenditure commitments (PC, 2014).

Authority to set strategic goals is local, due to the devolvement of disaster management and land use planning responsibilities in the Queensland Disaster Management Act (2003). The Act establishes a three-tier State, District and Local structure with planning responsibilities at each level, enacts coordination responsibilities at the state level, while devolving responsibility for implementation of CFRR measures to the local level.

Authority to set CFRR rules is state level. However, these are enacted as process-focussed planning rules, rather than regulating flood safety. The Queensland Coastal Protection and Management Act (1995) empowers the Queensland Government to identify and map land subject to coastal hazards, and to direct Local Governments to develop an adaptation strategy in high-risk areas. The Queensland Planning Act (2016) requires consideration of storm tide hazards in land use planning including projected SLR to 2100 (see Supplementary materials).

Authority for designing actual measures is thus fully devolved to the local level subject to State planning process requirements. Yet while the Disaster Management Act emphasises the need for identification and implementation of CFRR measures, specific works projects for CFRR remain absent from the local level plans.

Regarding fiscal control, authority in most sectors is shared between the federal and state levels. Yet for the coastal sector, most funding is focused on broader disaster resilience rather than physical CFRR measures. In 2017-2018, the Federal Government allocated AUD\$14 million to Queensland through the Natural Disaster Resilience Program to fund priority disaster resilience initiatives on the basis of matched investment from the State Government. Yet out of 72 projects funded, only one was dedicated to coastal protection measure. Thus, overall funding for CFRR is low in practice, CFRR budget setting and fund raising rests with local authorities. Indeed, Queensland Local Governments have traditionally financed CFRR measures through some combination of directly

levied property taxes, borrowings and state and federal government grants. Grants have been provided by other levels of government have been through both schemes targeted at natural hazard risk reduction and those with other focuses such as regional economic development.

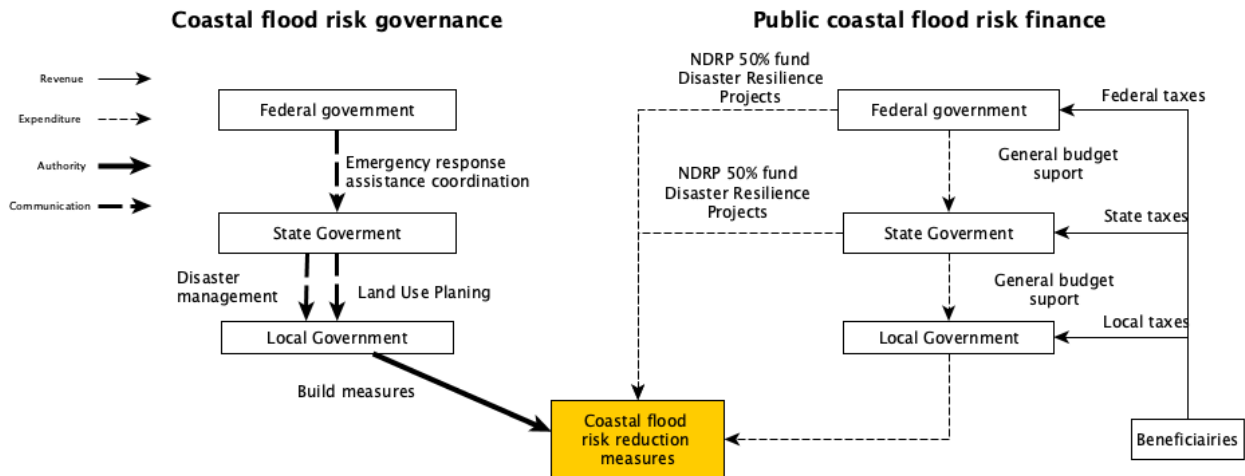


Figure 4. Coastal flood risk governance and public finance arrangements in Queensland, Australia.

5. Comparing multilevel coastal flood risk governance arrangements

5.1. Alignment of multilevel governance arrangements

		NL	England (UK)	Schleswig-Holstein (GER)		Queensland (AUS)
				State-dikes	Regional dikes	
Set strategic goal		National	National-Regional-Local	Regional	Local	Local
Set coastal risk reduction rules		National (Regulate)	National (Incentivise)	Regional (Regulate)	Regional (Incentivise)	National-Regional (Communicate)
Design measure		National	Local *	Regional	Local	Local
Fiscal control	Set public budget for capital measures	National	National-Local	National-Regional (GAK)	Regional-Local	Local
	Set tax base and rates	National	National-Local	Regional	Local	Local

* depending on embankment ownership.

Table 3. Locating of public decision-making and fiscal authorities for coastal flood risk reduction in the four countries.

Table 3 locates public authorities across three levels of government (national, regional, local), allowing us to characterise the centralisation/decentralisation in each country, and assess their alignment to spillovers of CFRR (Table 2). We find diverse MLG arrangements ranging from highly centralised (Netherlands), mixed arrangements involving regional centralisation (Schleswig-Holstein), or partial devolvment (England), to full decentralisation (Queensland). As introduced in Section 2, alignment of MLG arrangements describes the relationship between distribution of authority and the direct and indirect spillovers from CFRR.

In the Netherlands, governance is highly centralised, with all 4 dimensions of authority at the national level. Highly centralised funding arrangements thus cover 90% of investment costs funded either through general tax revenues or earmarked Water Authority fees. This appears to be well-aligned with very high direct (i.e. 9880 inhabitants per km of coastline) and indirect spillovers (i.e. coastal exposed assets to GDP ratio of 60%) (see Table 2). The social acceptance of such redistributions can be seen as evidence of recognition in the public sphere of these significant spillovers.

In Schleswig-Holstein, centralised decision-making authority is shared between federal and state level, consistent with the regional character of German federalism (Biesbroek et al. 2018). However, the dual State and Local Dikes system also means that part of the coast is governed in a decentralised manner. In the State Dike system, SH State has significant planning autonomy, as it formally sets the flood safety standard through the Master Plan. Fiscal control – CFRR budget setting – is shared between the Federal Government and all 16 States (*Länder*).

In terms of alignment, the State Dike system is entirely funded beyond the local level, and with 70% of investment costs covered at the national level. For SH, coastal exposed populations are very small as a share of the national population (0.13%), yet moderate as a share of the State population (3.85%) (see Table 2). Coastal population density is moderate indicating that direct spillovers exist, and provide an argument for centralisation at the State level. However, the significant federal funding appears less well-aligned, particularly under rising costs under SLR. We discuss this below

in Section 5.2.

In England, governance arrangements are moderately decentralised. Devolution of authority to design specific measures for CFRR is accompanied by explicit participation of different levels of government in Shoreline Management Plans (SMP) in which strategic goals are decided. Fiscal control is shared between national and local levels. However, national planning rules focusing on finance allocation, e.g. Partnership Funding, mean that in practice the national government retains significant decision-making authority. However, as noted, updated funding rules, which foresee an increase in funding provided for CFRR by the central government, will come into effect in April 2021.

In terms of alignment, over 90% of CFRR funding is national. Coastal exposed population as a share of the national population is intermediate between the low levels of Queensland and SH, and high levels of the Netherlands (Table 2). Coastal population density is slightly lower than that in SH. These indicators provide only moderate arguments for centralisation. Indeed, MLG arrangements in England reflect a mixed approach. Partnership Funding aims to reduce federal funding to 85% of CFRR measures (DEFRA, 2011), and can be seen as an effort to address a potential mis-alignment in MLG arrangements, given the low spillovers of CFRR for long and largely rural sections of the English coastline.

In Queensland, authority is decentralised. Local government has authority to design CFRR measures, constrained only by State and Federal process-focused planning rules requiring risk assessments incorporating SLR and climate change. Local governments are largely responsible for funding CFRR measures themselves. In terms of alignment, the relatively sparsely populated Queensland coast shows low direct and indirect spillovers, and thus such decentralisation appears to be well-aligned.

Finally, we note that the alignment question addressed here focuses on whether multilevel governance arrangements promote physical CFRR measures. A number of other dimensions of alignment of governance arrangements are relevant for governing coastal flood risk more broadly. For example, an analysis of the general revenue generation instruments, such as, property taxes, building permitting and value-added taxes, would shed light on incentives for coastal development that arise at different levels of government and thus whether multilevel governance arrangements can promote coastal development strategies that 'avoid' increasing coastal flood risk. While we cannot address such broader questions in the present paper, extending the analysis of alignment in multilevel governance arrangements to such other coastal adaptation strategies is an important direction for future research.

5.2. Outlook under future sea-level rise

Given that SLR will increase the costs of maintaining current protection levels, here, we discuss the outlook for current arrangements under future SLR. We note that the discussion below is generally applicable even under current coastal risk. For example, there is already evidence that German Baltic Sea communities have difficulties funding CFRR measures for protecting themselves against current risks (Wolff 2016; Bisaro and Hinkel 2019). Below, however, we focus on how SLR may exacerbate these issues.

First, centralised arrangements that exhibit mis-alignment between beneficiaries and funders are likely to come under increasing pressure from SLR. For example, centralised funding arrangements in Germany entail a significant re-distribution of federal funds to Schleswig-Holstein for its State Dikes. Currently, annual CFRR investment costs in SH are low as a share of the state and national budgets. However, SH uses a hazard-based safety norm ensuring that coastal areas protected by

State Dikes are protected up to a 1-in-200 year flood event (see Supplementary materials). The current Master Plan budgets the next 5 years of public CFRR investment. It sets out investments needed to maintain this 1-in-200-year safety level, while accounting for SLR of an additional 50cm in this century, a middle estimate of possible future SLR. To account for SLR uncertainty, the Master Plan also foresees dike widening to enable future heightening at lower cost (BMEL, 2018).

Rising protection costs under SLR, particularly under such a hazard-based safety norm may bring into question whether increasingly large federal funding support will be maintained. If SLR proceeds quickly and foreseen costs are revised upward, substantial federal funding of SH protection costs may need to be re-examined, given that the spillovers to the national economy are relatively small. Indeed, there have been previous efforts to improve alignment through, for example, aborted efforts to implement a coastal protection 'user fee' at the state level in SH (Wolff, 2016). As SLR increases protection costs, greater alignment of funding instruments and beneficiaries at the regional level may become more politically feasible because regional stakeholders may see a greater need for funding CFRR. Further, the need for SH to consider a risk-based approach, using, for example, use cost-benefit analysis, as opposed to the current hazard-based approach, to its Master Plan will become more salient.

Second, for decentralised arrangements, coastal communities may be overwhelmed by the increasing financial burden from SLR due to budget and capacity constraints (Moser et al., 2019), and resistance from local vested interests to raising new funds (Beatley, 2012). We already observe lower CFRR levels in decentralised arrangements, i.e. Queensland, SH Local Dikes, compared to centralised arrangements.

SLR will increase pressure on local governments' financial and technical capacities, and this problem can be addressed in different ways. On one hand, local CFRR may be enabled through comprehensive and transparent rules for central co-funding support, as, for example, in Partnership Funding in England. Rather than increasing overall central funding, these funding rules operate by increasing perceptions of fairness and providing clear financial incentives for measures designed at the local level. However, it is as yet too early to tell whether this approach can mobilise adequate local level funding in aggregate. On the other hand, the CFRR burden on local communities can be reduced through further centralisation. In Schleswig-Holstein, further State take-over of Local Dikes has a legal basis and is under discussion for several Baltic Sea locations (Bisaro and Hinkel, 2019). Barriers also emerge, however, as some communities have already declined State take-over because they do not wish to cede ownership of coastal land, and with it, decision-making authority over dike heights.

Finally, across all decentralised arrangements, alternative CFRR measures – other than protection – are likely to be considered. In England, coastal protection strategies aimed at holding the line would cost between £18-30 billion, nearly an order of magnitude larger than current total annual spending on all flood risks, while for 66km of shoreline holding-the-line gives a benefit-cost ratio of less than one (CCC, 2018). In Queensland, where low CFRR spillovers indicate that significant centralisation is unlikely, local financial constraints indicate communities may be forced to consider alternative strategies to protection for CFRR such as retreat and funding mechanisms involving private finance.

While all of this underlines the need for alternative strategies to protection, it also highlights the conundrum faced by national governments. From the perspective of fiscal federalism taken in this paper, there is a limited economic case for central governments to support CFRR in coastal communities of little importance to the national economy. Yet alternative strategies to protection, such as retreat, generally require support from higher levels of government. Existing examples of managed retreat strategies in practice, e.g. buy-out programs in the US (Greer and Brokopp Binder,

2017), and pilot buy-outs in the UK (Brennan, 2007), show they are unlikely to be chosen and implemented by local communities acting on their own. In absence of central support for such strategies, coastal communities may face large-scale human and social losses that go beyond the economic dimensions emphasised by fiscal federalism. Thus, central governments may have an important supporting role to play in enabling such alternative strategies, and have a mandate to do so, i.e. to avoid human suffering in coastal disasters, beyond the economic case examined here.

Acknowledgements

We acknowledge funding from the European Union's Horizon 2020 research and innovation program under Grant 642018 (GREEN-WIN project) and funding from the project INSeaPTION as part of ERA4CS, an ERA-NET initiated by JPI Climate, and funded by BMBF (DE), MINECO (ES), NWO (NL), and ANR (FR) with co-funding by the European Union (Grant 690462).

References

- Austin, S.E., Ford, J.D., Berrang-Ford, L., Biesbroek, R., Tosun, J., Ross, N.A., 2018. Intergovernmental relations for public health adaptation to climate change in the federalist states of Canada and Germany. *Global environmental change* 52, 226–237.
- Biesbroek, R., Lesnikowski, A., Ford, J.D., Berrang-Ford, L., Vink, M., 2018. Do Administrative Traditions Matter for Climate Change Adaptation Policy? A Comparative Analysis of 32 High-Income Countries. *Review of Policy Research* 35, 881–906. <https://doi.org/10.1111/ropr.12309>
- Biesbroek, R., Dupuis, J., Jordan, A., Wellstead, A., Howlett, M., Cairney, P., Rayner, J., Davidson, D., 2015. Opening up the black box of adaptation decision-making. *Nature Clim. Change* 5, 493–494.
- Bisaro, A., de Bel, M., Hinkel, J., Kok, S., Bouwer, L.M., 2019. Leveraging public adaptation finance through urban land reclamation: cases from Germany, the Netherlands and the Maldives. *Climatic Change*. <https://doi.org/10.1007/s10584-019-02507-5>
- Bisaro, A., Hinkel, J., 2019. Aligning coastal risk decision-making and funding responsibilities at the German Baltic Sea coast, in: *Responding to Rising Seas: OECD Country Approaches to Tackling Coastal Risks*. OECD Publishing, Paris, France.
- Bisaro, A., Hinkel, J., 2016. Governance of social dilemmas in climate change adaptation. *Nature Climate Change* 6, 354–359. <https://doi.org/10.1038/nclimate2936>
- Brennan, R., 2007. The North Norfolk coastline: a complex legacy. *Coastal Management* 35, 587–599.
- Bubeck, P., Kreibich, H., Penning-Rowsell, E.C., Botzen, W.J.W., De Moel, H., Klijn, F., 2017. Explaining differences in flood management approaches in Europe and in the USA—a comparative analysis. *Journal of Flood Risk Management* 10, 436–445.
- CCC, 2018. *Managing the coast in a changing climate*. Committee on Climate Change.
- Danielson, L., Seawert, A., Bisaro, A., 2019. Emerging approaches to coastal adaptation, in: *Responding to Rising Seas: OECD Countries Approaches to Tackling Coastal Risks*. OECD Publishing, Paris.
- DEFRA, 2018. *Central Government Funding for Flood and Coastal Erosion Risk Management in England* (No. Report PB13900).
- DEFRA, 2011. *Flood and Coastal Resilience Partnership Funding: Defra policy statement on an outcome-focused, partnership approach to funding flood and coastal erosion risk management* [WWW Document]. URL https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/221094/pb13896-flood-coastal-resilience-policy.pdf (accessed 2.19.19).
- DEFRA, 2006. *Shoreline management plan guidance* (No. Vols 1 and 2). Department for Environment, Food and Rural Affairs, London.
- Dupuis, J., Biesbroek, R., 2013. Comparing apples and oranges: The dependent variable problem in comparing and evaluating climate change adaptation policies. *Global Environmental Change* 23, 1476–1487. <https://doi.org/10.1016/j.gloenvcha.2013.07.022>
- Feeley, M.M., Kesari, A., 2017. *Federalism as Compared to What? Sorting Out the Effects of Federalism, Unitary Systems, and Decentralization*. *Sorting Out the Effects of Federalism, Unitary Systems, and Decentralization* (March 17, 2017). UC Berkeley Public Law Research Paper.
- GofQ, 2019. *Queensland Natural Disaster Resilience Programme*. Government of Queensland.
- GofQ, 2016. *Queensland Planning Act*. Government of Queensland.
- GofQ, 2003. *Queensland Disaster Management Act*. Government of Queensland.
- GofQ, 1995. *Queensland Coastal Protection and Management Act*. Government of Queensland
- Greer, A., Brokopp Binder, S., 2017. A historical assessment of home buyout policy: Are we learning or just failing? *Housing Policy Debate* 27, 372–392. Hinkel, Jochen, Daniel Lincke, Athanasios T. Vafeidis, Mahé Perrette, Robert James Nicholls, Richard SJ Tol, Ben

- Marzeion, Xavier Fettweis, Cezar Ionescu, and Anders Levermann. "Coastal flood damage and adaptation costs under 21st century sea-level rise." *Proceedings of the National Academy of Sciences* 111, no. 9 (2014): 3292-3297.
- Hallegatte, S., Green, C., Nicholls, R.J., Corfee-Morlot, J., 2013. Future flood losses in major coastal cities. *Nature Clim. Change* 3, 802–806. <https://doi.org/10.1038/nclimate1979>
- Hooghe, L., Marks, G., Schakel, A.H., Osterkatz, S.C., Niedzwiecki, S., Shair-Rosenfield, S., 2016. *Measuring regional authority: A postfunctionalist theory of governance*. Oxford University Press.
- IPCC, 2019. *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate*. IPCC.
- Javeline, D., 2014. The most important topic political scientists are not studying: adapting to climate change. *Perspectives on Politics* 12, 420–434.
- Jongman, B., Hochrainer-Stigler, S., Feyen, L., Aerts, J.C., Mechler, R., Botzen, W.W., Bouwer, L.M., Pflug, G., Rojas, R., Ward, P.J., 2014. Increasing stress on disaster-risk finance due to large floods. *Nature Climate Change* 4, 264–268.
- Jordan, A.J., Huitema, D., Hildén, M., Asselt, H. van, Rayner, T.J., Schoenefeld, J.J., Tosun, J., Forster, J., Boasson, E.L., 2015. Emergence of polycentric climate governance and its future prospects. *Nature Clim Change* 5, 977–982. <https://doi.org/10.1038/nclimate2725>
- Keenan, J.M., 2018. Regional resilience trust funds: an exploratory analysis for leveraging insurance surcharges. *Environ Syst Decis* 38, 118–139. <https://doi.org/10.1007/s10669-017-9656-3>
- Keenan, J.M., Chu, E., Peterson, J., 2019. From funding to financing: perspectives shaping a research agenda for investment in urban climate adaptation. *International Journal of Urban Sustainable Development* 11, 297–308. <https://doi.org/10.1080/19463138.2019.1565413>
- Kitchen, H., Slack, E., 2006. Providing public services in remote areas. *Perspectives on fiscal federalism* 123–139.
- Kuhlmann, S., Wayenberg, E., 2016. Institutional impact assessment in multi-level systems: conceptualizing decentralization effects from a comparative perspective. *International Review of Administrative Sciences* 82, 233–254.
- LWG, 2008. *Landeswassergesetz (State Water Act) des Landes Schleswig-Holstein vom 11. Februar 2008*.
- Merrill, S., Kartez, J., Langbehn, K., Muller-Karger, F., Reynolds, C.J., 2018. Who should pay for climate adaptation? Public attitudes and the financing of flood protection in Florida. *Environmental Values* 27, 535–557.
- Moser, S., Ekstrom, J., Kim, J., Heitsch, S., 2019. Adaptation finance archetypes: local governments' persistent challenges of funding adaptation to climate change and ways to overcome them. *Ecology and Society* 24. <https://doi.org/10.5751/ES-10980-240228>
- Mullin, M., Smith, M.D., McNamara, D.E., 2018. Paying to save the beach: effects of local finance decisions on coastal management. *Climatic Change* 1–15. <https://doi.org/10.1007/s10584-018-2191-5>
- Neumann, B., Vafeidis, A.T., Zimmermann, J., Nicholls, R.J., 2015. Future coastal population growth and exposure to sea-level rise and coastal flooding—a global assessment. *PloS one* 10, e0118571.
- Nicholls, R.J., Hinkel, J., Lincke, D., van der Pol, T., 2019. *Global Investment Costs for Coastal Defense through the 21st Century*. The World Bank.
- Oates, W.E., 2005. *Toward A Second-Generation Theory of Fiscal Federalism*. *Int Tax Public Finan* 12, 349–373. <https://doi.org/10.1007/s10797-005-1619-9>
- Oates, W.E. 1999. *An Essay on Fiscal Federalism*. *Journal of Economic Literature*, 37(3), 1120–1149. Retrieved March 11, 2020, from www.jstor.org/stable/2564874
- Oates, W.E., 1972. *Fiscal federalism*. Edward Elgar Publishing.
- Olson, M., 1969. The principle of "fiscal equivalence": the division of responsibilities among different levels of government. *The American economic review* 59, 479–487.
- Pauw, W.P., Klein, R.J.T., Vellinga, P., Biermann, F., 2015. Private finance for adaptation: do private

- realities meet public ambitions? *Climatic Change* 1–15. <https://doi.org/10.1007/s10584-015-1539-3>
- PC, 2014. *Natural Disaster Funding Arrangements* (No. Volume 1). Productivity Commission, Canberra.
- Penning-Roswell, E.C., Johnson, C., 2015. The ebb and flow of power: British flood risk management and the politics of scale. *Geoforum* 62, 131–142.
- Peters, B.G., 2014. The politics of bureaucracy [WWW Document]. *The Politics of Bureaucracy*. <https://doi.org/10.4324/9780203879146-10>
- Peters, B.G., Pierre, J., 2005. Swings and Roundabouts? Multilevel Governance as a Source of and Constraint on Policy Capacity, in: Painter, M., Pierre, J. (Eds.), *Challenges to State Policy Capacity: Global Trends and Comparative Perspectives*. Palgrave Macmillan UK, London, pp. 38–51. https://doi.org/10.1057/9780230524194_3
- Peterson, J., 2018. Multilevel Governance and Innovations in the Financing of Urban Climate Change Strategies, in: Hughes, S., Chu, E.K., Mason, S.G. (Eds.), *Climate Change in Cities: Innovations in Multi-Level Governance*, The Urban Book Series. Springer International Publishing, Cham, pp. 281–298. https://doi.org/10.1007/978-3-319-65003-6_14
- Preston, B.L., Mustelin, J., Maloney, M.C., 2015. Climate adaptation heuristics and the science/policy divide. *Mitigation and Adaptation Strategies for Global Change* 20, 467–497.
- Tenbenschel, T., 2005. Multiple modes of governance: Disentangling the alternatives to hierarchies and markets. *Public Management Review* 7, 267–288.
- Vafeidis, A.T., Nicholls, R.J., McFadden, L., Tol, R.S.J., Hinkel, J., Spencer, T., Grashoff, P.S., Boot, G., Klein, R.J.T., 2008. A new global coastal database for impact and vulnerability analysis to sea-level rise. *Journal of Coastal Research* 24, 917–924.
- Verhoest, K., Peters, B.G., Bouckaert, G., Verschuere, B., 2004. The study of organisational autonomy: a conceptual review. *Public Administration and Development* 24, 101–118. <https://doi.org/10.1002/pad.316>
- Wolff, A., 2016. *Multi-level Climate Change Adaptation Governance: Analysis of Coastal Flood Risk Management in the German Federal State of Schleswig-Holstein* (MSc Thesis). Humboldt University Berlin.
- Woodruff, S.C., Mullin, M., Roy, M., 2020. Is coastal adaptation a public good? The financing implications of good characteristics in coastal adaptation. *Journal of Environmental Planning and Management* 0, 1–20. <https://doi.org/10.1080/09640568.2019.1703656>
- Young, O.R., 2011. Effectiveness of international environmental regimes: Existing knowledge, cutting-edge themes, and research strategies. *Proceedings of the National Academy of Sciences* 108, 19853–19860.
- Young, O.R., 2002. *The institutional dimensions of environmental change. Fit, interplay and scale*. MIT Press, Cambridge, Massachusetts, USA.