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The politics of natural hazard preparedness and infrastructure: lessons for coastal climate adaptation public works

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Abstract

Coastal climate adaptation public works, such as storm surge barriers and levees, are central elements of many strategies to limit damages from coastal storms and sea-level rise. Academic analysis of such public works projects is dominated by technocratic and engineering-driven frameworks. However, social conflict and politics have been crucial in the conception, design, and implementation of other public infrastructure and natural hazard preparedness projects. In this review, we highlight the role of interest mobilization, political motivations, siting opposition, and flexible/adaptive decision-making in both creating and overcoming political obstacles. Better understanding the social and political factors that enable or hinder the implementation of adaptation works could encourage strategies and policies that are less likely to result in deadlocks, delays, or failure, thus saving valuable time and planning resources.

1. Introduction

Climate adaptation public works (hereafter, adaptation works) are engineered, structural infrastructure projects, initiated, designed, and implemented by governments, with the intention of reducing the economic and social burden of climate change. For example, rising sea levels (Sweet et al., 2017), expanding coastal development (Crossett et al., 2013; Neumann et al., 2015; Titus et al., 2009), and recent hurricane disasters have encouraged several U.S. cities to investigate strategies for managing coastal floods. Among these strategies are adaptation works such as storm surge barriers (Douglas Hill et al., 2012; Kirshen et al., 2020; Merrell et al., 2011; USACE, 2016, 2019). Storm surge barriers have proven to be technically viable options for densely populated areas to manage sea-level rise and coastal flooding (e.g., the Fox Point

Hurricane Barrier in Providence, Rhode Island; Fig. 1) (Aerts et al., 2014; Jonkman et al., 2013; Mooyaart & Jonkman, 2017; Morang, 2016; US National Research Council, 2014). Densely populated regions often lack the space to take advantage of nature-based strategies (e.g., wetland restoration) and other coastal adaptation options (e.g., managed retreat, informed land-use planning, building codes, and insurance) can conflict with goals for local development. While contemporary and historical plans for storm surge barriers, sea walls, and levees in the U.S. are numerous (City and County of San Francisco, 2016; City of New York, 2013; GCCPRD, 2018; Secretary of the Army, 1965, 1966; Sustainable Solutions Lab, 2018a; USACE, 2016, 2018a, 2018b, 2019, 2020), few have broken ground, even when technoeconomic analyses by entities such as the U.S. Army Corps of Engineers (USACE) indicate that they are technically feasible and economically beneficial. A better understanding of the political factors that determine whether adaptation works succeed or fail could allow projects to be designed and executed in a more efficacious and less costly manner.

Existing research on why plans for adaptation works ultimately do or do not break ground focuses on identifying complex processes and interactions and classifying them into various adaptation barriers or enablers. Moser & Ekstrom (2010) define adaptation barriers as "… impediments that can stop, delay, or divert the adaptation process" (Biesbroek et al., 2014; Eisenack et al., 2014; Klein et al., 2014). These barriers have been identified at stages related to project conception, design, and implementation (Figure 2) (S. C. Moser & Ekstrom, 2010). Among these hinderances is social conflict resulting from interactions between diverse groups, organizations, and communities with heterogenous values, beliefs, interests, and influence (Adger et al., 2009; Dolšak & Prakash, 2018; Eakin et al., 2017; Eriksen et al., 2015; Leiserowitz, 2006; Sovacool & Linnér, 2016). In addition to barriers that can hinder adaptation works, enablers have been put forward as a way to overcome some of these challenges (Dutra et al., 2015; Dyckman et al., 2014). Examples include stakeholder participation and improving coordination between government agencies (Few et al., 2007; Rabe, 1995).

While assessments that identify conceptual barriers and enablers are important, remaining key challenge include 1) determining which barriers are likely to manifest and under what contexts and 2) ascertaining which enablers would effectively address them. Specificity matters, because the objective and physical size of an adaptation works project is likely to 1) influence which barriers are encountered in the policy process and 2) determine the ways to overcome them (S. C. Moser & Ekstrom, 2010). For this reason, empirically informed literature reviews are needed. While many exist for different adaptation arenas (Biesbroek et al., 2014, 2015; Bisaro & Hinkel, 2016; Hinkel et al., 2018; Measham et al., 2011; Sieber et al., 2018; A. Wellstead et al., 2014), none are specific to coastal adaptation megaprojects like storm surge barriers. This is in part because implementation of adaptation works in the U.S. has been slow, and so existing cases are few (Bierbaum et al., 2013; Lesnikowski et al., 2013; Woodruff & Stults, 2016).

Coastal adaptation strategies – especially storm surge barriers and other engineered coastal defenses (US National Research Council, 2014) – are largely extensions of existing practices to manage flooding outside of a climate change context (Sovacool & Linnér, 2016). Thus, several decades of empirical research in the natural hazards literature can inform how and why adaptation works initially get placed on government agendas (Thomalla et al., 2006), and existing studies on public works can inform the design and implementation stages and also

help understand why projects sometimes fail to break ground. Examples of related areas include the politics of "megaprojects" (Altshuler & Luberoff, 2003; Buzbee, 2014; B Flyvbjerg et al., 2003), opposition to harbor dredging and filling (Buzbee, 2014; Kagan, 1991), and the design and implementation of flood protection outside of a climate change context (Bligh, 2006; Disco, 2002; Morang, 2016).

The division of political power within a country plays a fundamental role in assessing how politics adds complexity to an adaptation works project. For example, federal systems like the U.S. that divide planning authority in a manner that protects the sovereignty of sub-national states differ from unitary governments, where planning is the sole responsibility of a central governing body (Austin et al., 2018; Elazar, 1987). In the U.S., the division of powers can complicate coordination and intergovernmental relations, especially when states and municipalities rely on financial and technical resources from the federal government (Glicksman, 2010). We specifically focus on the U.S., but our findings are relevant to adaptation works in other democracies in which the responsibility for managing natural hazards is split between a central governing body and constituent units (e.g., states/providences or municipalities).

The following review, while not comprehensive in nature, gives examples – primarily from the natural hazard preparedness and infrastructure literatures – of where politics plays a role in the conception (Section 2), design (Section 3), and implementation (Section 4) stages of coastal adaptation projects. These stages are chosen for organizational purposes only. They are loosely based off those used by Moser and Ekstrom (2010) to delineate adaptation implementation and those devised by (Kingdon, 2011) to describe the policy process. In reality, the stages of an adaptation works project may not occur in this order or be as clearly defined. Following our review, we give suggestions for how future adaptation works could deal with political complexities and recommend future research directions (Section 5).

2. The decision to pursue adaptation works

All adaptation works projects begin when the decision to initially explore options appears on a government agenda (a range of problems to which government officials are paying serious attention to at a given time). There are many possible ways in which an adaptation works project can appear on an agenda. For example, the state or local government may simply require action, the federal government may offer financial incentives, an extreme weather event may highlight a need for adaption works, or groups and/or prominent leaders may advocate for action. On the other hand, political incentives can also discourage adaption works from landing on an agenda or advancing to subsequent stages of planning.

2.1 How adaptation works can arrive on the government agenda

In the U.S., the federal government does not have the authority to coerce states and local communities to meet coastal flood safety standards (US National Research Council, 2014); this is in contrast to other environmental domains with federal standards, such as water and ambient air quality (Downing & Kimball, 1982). However, Congress has created various federal programs to incentivize local preparedness by 1) making grants available to states and local

communities to finance projects they would otherwise not be able to afford through local tax revenues and debt issuances alone and 2) reducing premiums for government-sponsored insurance programs if communities undertake risk-reduction measures (for example, through the National Flood Insurance Program's Community Ratings System) (Carter, N. T. et al., 2019). Federal grants are available either following a natural disaster [e.g., Federal Emergency Management Agency's (FEMA) Hazard Mitigation Program and the Department of Housing and Urban Development's (HUD) Community Development Block Grant (CDBG) Program] or *ex ante* [e.g., FEMA's Mitigation Assistance Program and Building Resilient Infrastructure and Communities (BRIC) – formerly the Pre-Disaster Mitigation Program]. In both cases, recipients are required to have a standing FEMA-approved hazard mitigation plan in order to be eligible. While meager annual budgets (appropriations < $250 million/yr) restrict FEMA support for adaptation works (Carter, N. T. et al., 2019), grants through HUD can be larger. For example, HUD awarded New York City over $300 million through the Rebuild by Design competition to assist with funding the $1.45 billion East Side Coastal Resiliency Project (City of New York, 2020). But overall, federal funding is 1) often tied to specific disasters, making it inaccessible to communities not impacted, 2) is contingent on annual congressional appropriations, leading to fluctuations in the levels of support, and 3) is minuscule compared to that needed to fund storm surge barriers and other large public works. For these projects, substantial federal assistance is needed from either Energy and Water Development appropriations acts or emergency appropriations acts following disasters (Carter, 2018; Knopman et al., 2017; Sustainable Solutions Lab, 2018b; US National Research Council, 2014).

A perennial challenge for natural hazard preparedness has been mobilizing support for action. Historically, local governments have tended to view extreme weather events (e.g., floods, hurricanes, tornados) and other rare hazards (e.g., earthquakes, wildfires, pandemics) as minor problems that take a backseat to more frequent and visible issues like unemployment, crime, housing, and education (Birkland, 1996; Burby, 2006; May, 1985; Rossi et al., 1981, 1982), despite acknowledgement of risks (White et al., 2001). However, evidence has shown the salience—or level of perceived importance—of preparedness rises through the occurrence of a disaster and by those who advocate for action (Birkland, 1996). As the salience of risks increase, so does the likelihood of efforts to address them. Indeed, more frequent coastal floods and other extreme weather events attributed to climate change are increasing the salience of responses (Demski et al., 2017).

In one model of the policy process, floods, hurricanes, and other extreme weather events have been viewed as "focusing events", whereby they refocus the attention of elected officials and publics on an existing problem (Birkland, 1996; Kingdon, 2011). During a focusing event, a "policy window" of opportunity opens for a short period, and advocates race to push their preferred solutions through before the window closes (Birkland, 1996; Christoplos, 2006; Kingdon, 2011). If no viable solutions reach government officials while the window is opened, changes are unlikely (Kingdon, 2011). Sometimes, multiple disasters are needed to increase issue salience enough to push a solution through (Birkland, 1996; Kingdon, 2011). Cumulative learning helps reinforce lessons (Sadowski & Sutter, 2008). For example, despite destructive hurricanes in 1938 and 1944, New England did not begin to address coastal flooding with public works until Hurricane Carol in 1954. This was in part due to exogenous economic and geopolitical events, such as the Great Depression and World War II (Morang, 2016). Hurricanes

and other focusing events also encourage the emergence of advocates who stimulate policy change (Olson, 1971).

Advocacy coalitions are groups whose goal is to increase the perceived importance of a particular policy issue and to encourage the adoption of strategies in order to meet their policy objectives (Sabatier, 1988). Advocacy coalitions for natural hazard risk management have been slow to emerge in part due to the technical nature of the hazards themselves, which has limited their study largely to scientific communities in government and academia (Birkland, 1997; May, 1991b). For instance, few public interest groups focused on hurricanes particularly exist in the U.S. (Birkland, 1997). Such "policies without publics" (May, 1991a) constrain the response following future extreme weather events, or lead to inefficient policies (Birkland, 1997). In the absence of sufficient citizen attention, the federal government has formed and supported groups that promote natural hazard preparedness in the public's interest (e.g., the U.S. National Earthquake Hazards Reduction Program[1] (Birkland, 1997)). However, creating federal advocacy groups has proven to be challenging; an attempt to create a government-sponsored technical group for hurricanes was made but ultimately failed due to a lack of congressional support (the National Hurricane Research Initiative; (National Science Board, 2007).

In additional to organized groups, the emergence of high-profile individuals as "policy entrepreneurs" can raise the salience of an issue or sustain interest. Policy entrepreneurs who are government executives can push their own agendas to address issues that they believe to be important (Kingdon, 2011; Susanne C. Moser et al., 2019; Renner & Meijerink, 2018; J. B. Smith et al., 2009). For example, in the wake of Hurricane Sandy, New York City Mayor Michael Bloomberg championed natural hazard preparedness efforts, such as the Special Initiative on Rebuilding and Resiliency and the creation of the Mayor's Office of Resiliency and Recovery[2]. However, subsequent leadership must continue to value climate adaptation in order to sustain implementation, which can sometimes take decades (Section 4). Policy entrepreneurs that advocate for adaptation works may leave office and then new leaders might scrap the plans of the previous leadership because the projects do not align with their goals (Kingdon, 2011). While focusing events, advocacy coalitions, and policy entrepreneurs can all add adaptation works to an agenda, countervailing political incentives can discourage it.

2.2. Political incentives can hinder efforts to create adaptation works

Political incentives can discourage elected officials from reducing exposure to coastal hazards and also from promoting protective measures. For instance, the short time scales of election cycles can encourage politicians to focus on contemporary societal welfare at the expense of the future (Jacobs, 2016). If the primary goal of an elected official is to get re-elected (Mayhew, 1974), then it is rational for them to address problems with benefits that are visible to their constituents during their time in office. This includes favoring disaster relief over preparedness (Gasper & Reeves, 2011; Healy & Malhotra, 2009; Posner, 2006). Disaster relief can be distributed in the weeks to months following a disaster, while adaptation projects can take years to plan and implement and may only positively impact a small fraction of the voting

[1] https://www.nehrp.gov/

[2] https://www1.nyc.gov/site/sirr/report/report.page

population. An electorate may only come to appreciate the preparedness measures after they successfully mitigate a disaster, which could be years—if ever—long after the incumbent vacates office. For example, the villagers of Fudai, Japan praised a tsunami protection structure following the Tōhoku Earthquake in 2011 after previously labeling it a boondoggle and ridiculing the mayor who championed its construction (Daily Mail, 2011). Ultimately, without the willpower from elected officials to pay upfront political costs in order for publics to receive net returns in the future, the status quo is likely to endure.

The U.S. faces a preparedness dilemma that can inhibit adaptation works: while the federal government seeks to protect citizens from natural disasters, it has limited control over efforts to do so. Both the vulnerability to and consequences of a coastal hazard are largely shaped by state and local land use and building codes (Simmons et al., 2018; US National Research Council, 2014). For instance, local jurisdictions may be incentivized by the potential benefits from economic growth to develop lands exposed to hazards (e.g., coastlines) (Burby, 2001; Knowles & Kunreuther, 2014; Peterson, 1981; Stone, 1989). At the same time, local jurisdictions bear reduced responsibility for protecting vulnerable and exposed developments, in part due to the expectation of federal aid (e.g., disaster relief), which takes pressure off local officials to set aside surplus revenue for unexpected events (Rossi et al., 1982). In essence, the rewards of high-risk development accrue to property developers and local and state governments in the form of employment, contracts, profits, and tax revenue, while the federal government is largely responsible for disaster aid. This misalignment of risks, rewards, and responsibility between federal and local governments can suppress local interest in pursuing adaptation and remains an enduring challenge to overcome (Burby, 2006; US National Research Council, 2014). In the U.S., some efforts have been made to discourage development on coastal lands (e.g., the Coastal Barrier Resources Act and the Coastal Zone Management Act), but new construction continues in these areas (Climate Central and Zillow, 2018; Lazarus et al., 2018; US National Research Council, 2014).

3. Designing adaptation works

Once governments have decided to address a physical climate hazard (Section 2), they must determine how to do so. Multiple solutions are usually possible. In addition to building surge barriers and other defense measures, options to adapt to coastal floods and sea-level rise include elevating structures to accommodate extreme water levels and moving populations and the built environment away from the coastline (M. Oppenheimer et al., in press). Either a single strategy or combination of strategies could be chosen. In the U.S., the National Environmental Policy Act (NEPA) requires that government agencies consider more than one proposed solution if a proposed project poses significant harms to the quality of the natural environment (Luther, 2008). Ultimately, selecting a proposal can be broken into two steps: 1) producing alternative strategies and 2) choosing among them. Creating a viable project is not simply a matter of skillful engineering and a favorable benefit-cost ratio. Experience with infrastructure and harbor projects suggest that social conflict is likely to be a factor (Buzbee, 2014; Disco, 2002; Fukuyama, 2017; Howard, 2015; Kagan, 1991; Sovacool & Linnér, 2016).

3.1. Creating alternatives

Proposed adaptation solutions are likely to be based on aims that reflect their designers' values and beliefs about what constitutes "good" options, not necessarily specific technical objectives (Sovacool & Linnér, 2016). Examples of the latter include protecting the greatest amount of assets or the largest number of people while minimizing the net present value of the coastal defense structure. It is generally impossible to accommodate the values, beliefs, and desires of all stakeholders involved in determining what solution to employ (Few et al., 2007). Disagreements are likely. For example, experience with storm surge barriers has shown that these projects address some risks (e.g., harm from coastal floods) by way of disregarding others (e.g., harm to the natural environment; (Bijker, 2002; Disco, 2002; Providence Journal, 1965)). Adaptation choices inherently involve difficult tradeoffs between the present and the future; success in the near-term may be maladaptive in the long-run, and vice-versa (Barnett & O'Neill, 2010). Pareto optimal solutions that benefit all stakeholders are often unobtainable; while projects may be forecast to create net positive social welfare gains, underneath there are likely "winners" and "losers" (Sovacool & Linnér, 2016).

3.2. Choosing among alternatives

Decision analysis methods are formal approaches designed to help identify project alternatives that perform best with respect to given objectives. Examples include benefit-cost analysis (Chambwera et al., 2014) and robust (Lempert et al., 2003) and flexible/adaptive (Haasnoot et al., 2013, 2019; Ranger et al., 2013) decision-making. The appropriateness of each method depends on policy goals, available information, planning resources, and technical capabilities (Kleindorfer et al., 1993).

While decision analysis methods appear to facilitate a rational approach for choosing among project alternatives, they inherently involve normative choices that can greatly influence outcomes. For example, the selection of the decision-making objective reflects the decision-maker's view of how strategies are to be evaluated. The US federal government mandates the use of benefit-cost analysis (BCA), which considers the objective of maximizing the expected net present value (NPV). BCA has many well-known limitations (Chambwera et al., 2014), including strong sensitivity to chosen discount or interest rates, limited ability to account for uncertainty and for equity and other distributional effects, and limited or no inclusion of hard-to-monetize benefits and costs (e.g., to ecology or culture). Choices about how these limitations are handled can be manipulated to obtain desired outcomes (Bent Flyvbjerg, 1998; Bent Flyvbjerg et al., 2002; D. A. Mazmanian & Nienaber, 1979; Wachs, 1989, 1990). Scarcity of funding (e.g., grants) can encourage such "strategic misrepresentation" (Bent Flyvbjerg, 2007).

Instead of selecting projects that maximize expected NPV, robust decision-making (Lempert et al., 2003) and flexible/adaptive decision-making (Haasnoot et al., 2013, 2019; Ranger et al., 2013) identify strategies that perform well under uncertainty. For example, robust decision-making identifies alternatives that perform well under a wide range of parameter assumptions and plausible future states-of-the-world (i.e., "are robust"). However, differences in costs, values, beliefs, and interests could all lead to disagreements between stakeholders over what is the "best" strategy. Even if the same outcome is agreed upon (e.g., protection from a 100-yr flood), robust decision-making and flexible/adaptive decision-making do not necessarily

encourage consensus for choosing a course of action. Ultimately, they are dependent on value judgements by analysts, policymakers, and stakeholders.

Certain laws, regulations, and arrangements of governing bodies can also influence choices among presented alternatives. For instance, besides being cheaper, small-scale adaptation projects that could be implemented quickly may be favored over larger adaptation works that could take decades to complete, in part due to lengthy government approval and appropriations processes and long construction times. Large, engineered projects like levees and surge barriers require multiple acts of Congress before construction can begin (Carter & Normand, 2019). On the other hand, simple, small-scale adaptation projects can be undertaken at the discretion of the USACE, without the need for both approval and appropriations from Congress (Carter & Normand, 2019; Normand, Anna E., 2019). Projects like dune building, beach nourishment, and aquatic ecosystem restoration also have local-federal cost sharing schemes that are more favorable to local jurisdictions (Mullin et al., 2018; USACE-IWR, 2003) and may be preferred in decision-making frameworks that aim to keep future options open (e.g., Haasnoot et al., 2013, 2019). Shore- and nature-based alternatives can challenge the use of storm surge barriers as strategies, especially if no specific protection level is mandated. For example, advocating instead for shore-based resilience measures such as floodable waterfront parks and temporary flood barriers in Boston and New York City that have co-benefits that address social justice and other issues (Elizabeth Royte, 2019; Kirshen et al., 2020).

4. Implementing an adaptation works project

The design and selection of any adaptation project (Section 3) is not itself sufficient to assure its implementation. Based on past experiences with public works, implementation is likely to be challenged by environmental protection laws, public opposition, institutional complexity (e.g., permitting), and leadership continuity (Fukuyama, 2017; Kingdon, 2011; S. C. Moser & Ekstrom, 2010; Susanne C. Moser et al., 2019; Pressman & Wildavsky, 1984). Compared to smaller-scale adaptation options that are cheaper, reversible, or more flexible/adaptable (Haasnoot et al., 2013; Ranger et al., 2013), implementation is more difficult for infrastructure-based adaptation because of high, upfront costs to taxpayers and because infrastructure decisions are long lived and largely irreversible. For these reasons, adaptation works require substantial confidence in forecasted benefits before implementation becomes politically feasible. In the coastal domain, such confidence is challenged in part by uncertainties in projected ecological impacts of coastal infrastructure (Orton et al., 2019; Swanson et al., 2012) and projections of future sea-level rise characterized by “deep uncertainty” (Kopp et al., 2019). Despite these and other implementation challenges, storm surge barriers have been built in the U.S., including at Fox Point (completed in 1966; Providence, Rhode Island), New Bedford (completed in 1966; New Bedford, Massachusetts), Stamford, Connecticut (completed in 1969), Lake Borgne (completed in 2013; New Orleans, Louisiana), and additional smaller structures (for a complete U.S. list, see Morang, 2016). The projects completed in the 1960s benefited from preceding contemporary environmental laws that elevate oppositional viewpoints (Luther, 2008; D. A. Mazmanian & Nienaber, 1979). The Fox Point project additionally received strong, sustained support from both the public and elected officials

(Providence Journal, 1958, 1959, 1960). In the Lake Borgne case, some environmental policy procedures were exempted as a result of Hurricane Katrina (CRS, 2006; Luther, 2006).

4.1. *Environmental protection laws*

Experience with public works suggests that laws related to environmental protection provide opportunities to challenge the implementation of coastal adaptation works (Biesbroek et al., 2011; Bijker, 2002; Bligh, 2006; Disco, 2002; Luther, 2006; Scarano, 2013). Prior to the passage of contemporary environmental laws in the U.S., by and large the only legal question that proponents of a flood protection project usually needed to answer was if it would impede maritime navigation (Scarano, 2013). Today, mandatory consideration of environmental impacts has made infrastructure implementation a more complex legal process (D. A. Mazmanian & Nienaber, 1979). Under NEPA, all federally funded projects that pose significant harms to the quality of the natural environment must analyze and publicly disclose a proposal's environmental impacts through an environmental impact statement (EIS) and receive public comment on the proposal and its alternatives (Luther, 2008). While this process is not a direct legal barrier to project implementation per se, the transparency of potential ecological harms it provides can trigger public opposition (Buzbee, 2014). On the other hand, some environmental laws could block projects altogether. Under the Clean Water Act, projects cannot be built in coastal waterways unless 1) the sponsoring agency proves they need to be built in the water or 2) the underlying project will not cause "significant degradation" to important aquatic habitats (Copeland, 2016).

By expanding standing for litigation, NEPA has been wielded to secure significant litigation powers by citizens and environmental organizations that otherwise have no direct influence over the fate of projects. This includes the filing of lawsuits by such groups if they believe the submitted EIS does not sufficiently account for environmental impacts (Luther, 2008). These powers have threatened or derailed public works implementation on the grounds that they could harm water quality, fisheries, and recreation (e.g., (Kagan, 1991, 2001; Murchison, 2007)). For example, in New York City, the Sierra Club successfully sued and blocked an effort to issue an landfill permit as part of the Westway Project, a planned Manhattan superhighway (Buzbee, 2014). While there is little doubt that the emergence of the environmental protection movement greatly reduced air and water pollution, it has led to a number of new laws, regulations and lengthy, formalized processes that have the potential to challenge the implementation of adaptation works, much in the same way it has challenged the deployment of public works in general (Fukuyama, 2017; Luther, 2008).

4.2. *Infrastructure siting*

Despite the well-intentioned benefits of adaptation works, the siting of some projects is likely to raise public opposition [e.g., not-in-my-backyard (NIMBY) syndrome (McAvoy, 1999)]. NIMBY syndrome can present problems for governments trying to construct public works that aim to increase the welfare of its citizens broadly, but also imposes direct net costs on some groups given their geographic proximity. These projects are perceived by local citizens to bring few, if any, direct benefits while imposing large immediate costs via eminent domain, decreases

in property value, deterioration of the natural environment, and loss of amenities (Aldrich, 2008; McAdam & Boudet, 2012; Quah & Tan, 2002). As such, projects are often sited near communities with less political and economic power, raising environmental justice concerns (Aldrich, 2008). Examples of controversial projects that are meant to address broad societal welfare are hazardous waste facilities, airports, and renewable energy projects, such as dams and wind farms (Aldrich, 2008; Devine−Wright, 2011; McAvoy, 1999; E. Smith & Klick, 2007). While there is some flexibility in the siting of most projects that stimulate NIMBY responses, coastal adaptation works are tied to specific geographic areas for technical reasons. For example, the siting of storm surge barriers is largely limited to entrances to tidally influenced rivers or estuaries (Mooyaart & Jonkman, 2017), although bolder options have been proposed, such as an 8-km barrier from Sandy Hook, New Jersey to Breezy Point, New York (USACE, 2019). Siting in coastal regions is difficult in part because they are often either already developed due to high land values (e.g., New York City; (USACE, 2019)), have heavy maritime traffic, or are preserved ecological areas (e.g., the Eastern Scheldt in the Netherlands; (Disco, 2002)). NIMBY opposition to public works projects is expected to increase over time due to less available undeveloped lands, rising educational levels that lead to greater access to technical information and legal resources, increased environmental awareness, and declining confidence in government (Aldrich, 2008). Other siting-related environmental justice dilemmas can manifest when determining who is afforded protection from adaptation works and who is left out (Adger et al., 2006) and who may be subject to floodwater redistribution (e.g., giving consideration to traditionally marginalized groups and those of lower economic standing; Liao et al., 2019).

Incorporating stakeholder values and beliefs can resolve some siting opposition issues (Few et al., 2007; Gregory & Keeney, 1994; Kraft & Clary, 1991; D. A. Mazmanian & Nienaber, 1979). In the Netherlands, the original Delta Works plan to close off the Eastern Scheldt Estuary with an impermeable dam invoked strong public opposition from yachters, the shellfish industry, and environmental groups (Disco, 2002). In response, engineers and environmental scientists worked together to design an alternative that simultaneously served the interests of safety, economy, and ecology. The result was a storm surge barrier across the Eastern Scheldt with closeable gates wide enough to not significantly impede the natural tidal flow and therefore minimize the environmental impact (Bijker, 2002; Disco, 2002).

4.3. *Governance structures: fragmented decision-making and prospects for flexible/adaptive approaches*

Fragmented arrangements of government agencies and institutions hinder the implementation of adaptation works by complicating coordination, blurring responsibility (thus discourage accountability), and encouraging the production of sometimes contradictory sets of hazard information (Den Uyl & Russel, 2018; Fukuyama, 2017; Lubell, 2017). For example, in the U.S. there are at least nine federal agencies with responsibilities for managing coastal storm risks and 16 congressional subcommittees that can authorize projects or appropriate funds (USACE, 2015). Each agency has different geographic jurisdiction, regulatory authority, and capacity. Authority is additionally duplicated at the state and local levels and requires that projects pass review not only on the national stage, but also at the state and local level (e.g.,

the California Environmental Quality Act, the California equivalent of NEPA). This structure produces fragmented decision-making and a lack of coordination, potentially leading to a "vetocracy" if many diverse interests are involved (Fukuyama, 2017) with strongly held, divergent views. When considering coastal adaptation works in the San Francisco Bay Area, surveyed stakeholders almost unanimously favored more central coordination and integrated planning but disagreed on the preferred arrangement of governing authorities (Lubell, 2017). A key question is how to achieve cooperation within complex, multi-level systems. Possible approaches include integration and consolidation of permits (Rabe, 1995) and agencies, creating new agencies with extensive authority over coastal adaptation issues, and physical climate data centers to minimize duplication in the production of estimates of coastal flood hazards (Lubell, 2017).

When forced to adapt to a changing climate, some long-standing bureaucracies may no longer operate effectively. Without fundamental changes and restructuring, these legacy institutions will hinder society's ability to adapt to climate change (Libecap, 2011; Lubell, 2017). Potential reforms include restructuring institutions and their funding streams to accommodate flexible/adaptive designs (Haasnoot et al., 2013, 2019; Ranger et al., 2013). By facilitating short-term commitments to adaptive and flexible measures, such approaches address the issue of how to design coastal flood protection that maintains a given level of safety under uncertain projections of future flood risk (Haasnoot et al., 2013, 2019; Ranger et al., 2013). They can also avoid lock-in and reduce near-term costs while keeping future options open for adjustments that improve project performance (de Neufville & Scholtes, 2011). In England, the Thames Estuary 2100 project is addressing uncertainty in future flood risk using an iterative learning process that manages contemporary risks while avoiding strategies that limit future risk management options (Environment Agency, 2012; Ranger et al., 2013). But while similar flexible/adaptive approaches have appeared in some climate action strategies in the U.S. (Rosenzweig & Solecki, 2014), they have not been widely implemented (Woodruff & Stults, 2016).Obstacles include availability of financing for preparedness only following a disaster (Healy & Malhotra, 2009; Sustainable Solutions Lab, 2018b; US National Research Council, 2014) and inadequacy of current flood protection revenue streams for supporting either new construction or regular upgrades that would occur with a flexible/adaptive approach (Carter & Normand, 2019; Knopman et al., 2017; Sustainable Solutions Lab, 2018b). Flexible/adaptive approaches that involve sequences of decision and implementation over time may also be more expensive than single-decision design, particularly in the near term, and their successful execution depends upon the longevity of appropriately empowered institutions (Fankhauser et al., 1999; Haasnoot et al., 2019). On the other hand, avoiding early, fixed investments when they turn out to be needed can also prove costly (Fankhauser et al., 1999).

5. Potential remedies and ways forward

The prospects for breaking ground on storm surge barriers, levees, and other coastal adaptation megaproject in the U.S. are not solely a function of technically feasible and economically justifiable plans. Projects are deeply embedded in politics -- struggles between diverse groups, organizations, and communities with heterogenous values, beliefs, interests, and influence (Adger et al., 2009; Dolšak & Prakash, 2018; Eakin et al., 2017; Eriksen et al.,

2015; Leiserowitz, 2006; Sovacool & Linnér, 2016). Decisions over adaptation works are likely to involve difficult trade-offs between groups that may be impossible to reconcile equitably or arrive at a Pareto-optimal outcome. We use the natural hazard preparedness and infrastructure literature to provide examples of how political challenges may arise during the phases of conception (Section 2), design (Section 3), and implementation (Section 4) before breaking ground on a project. Our analysis also highlights past experiences in which these political obstacles have been overcome and projects have gotten built (Section 4). We suggest four ways in which future adaptation works could deal with existing political complexities in the U.S.:

1. *Prepare adaptation plans in advance of extreme weather events.* Natural disasters can highlight existing policy problems. This can increase attention from elected officials and trigger generous funding from central governments. Having carefully thought out plans for adaptation works in advance can increase the likelihood of implementing solutions when a window of opportunity opens (Kingdon, 2011). Analogous to advocacy coalitions for natural hazards (Birkland, 1997), climate adaptation advocacy groups could aid in the effort to produce such plans by identifying and empowering groups who may benefit from adaptation projects (e.g., populations in harm's way, the construction industry and unions).

2. *Address political incentives that discourage adaptation works.* The federal government must work to align risks, rewards, financing, and responsibility between central governing authorities and states and municipalities by 1) creating policies that respect state and municipal autonomy while enhancing accountability in use of federal funding, 2) continuing to provide disaster relief, and 3) promoting local commitments to proactive risk reduction (May, 1991a). Elected officials may be more likely to support adaptation projects if voters perceive a potential risk-reducing project as responsible government action, such as when there is clear and visible potential for disaster (Neumayer et al., 2014). Boundary organizations (e.g., academic institutions and extension networks, NGOs) could also educate voters or potential policy entrepreneurs on viable options to protect their communities from climate change (Gavazzi & Gee, 2018; Kopp, 2019). This would encourage elected officials to raise the importance of adaptation on their political agendas. Additionally, increasing federal grant opportunities should, in theory, incentivize planning, with the level of encouragement scaling with 1) the amount of financial assistance offered and 2) in the case of grants, the perceived competitiveness of a jurisdiction's application.

3. *Reform institutions to accommodate flexible/adaptable infrastructure approaches.* Flexible/adaptive approaches to adaptation works can help address design and planning challenges related to future uncertainties (Haasnoot et al., 2013, 2019). While governments should incorporate flexible/adaptable decision-making approaches into adaptation guidance (Environment Agency, 2012; Lawrence et al., 2018; Rosenzweig & Solecki, 2014), past decisions, infrastructure, and legacy institutions may not be well-suited to support these techniques. For instance, adaptation works can costs billions of US dollars, yet local jurisdictions often have limited access to the revenue-raising power

of central governments, except following a major disaster (Healy & Malhotra, 2009; Sustainable Solutions Lab, 2018b). This complicates efforts to fund flexible/adaptable projects that require scheduled adjustments over time. Numerous local revenue-raising options have been proposed (Sustainable Solutions Lab, 2018b), including increases in property taxes that are proportional to project benefits. Learning opportunities are available from financing water resource projects (Barrow & Hogan, 1996; Gerlak, 2006; Mullin & Daley, 2018; Wojtenko et al., 2003). Additionally, establishing standing agencies to carry out flexible/adaptable decision-making approaches could overcome the transient nature of political administrations (e.g., New York City's Office of Recovery and Resiliency).

4. *Engage the public when designing and siting infrastructure projects.* Public opinion should be taken seriously if "regulatory wars" are to be avoided and adaptation works are to break ground on schedule (Buzbee, 2014). Environmental laws can elevate the power of citizens and NGOs who may view projects as threats to natural resources or have narrower NIMBY concerns (Buzbee, 2014; Luther, 2008). Rather than top-down, state-directed approaches for the siting of controversial facilities, relevant stakeholders could be given opportunities to develop, discuss, and promote alternative options (Few et al., 2007). Pursuing a more deliberate process, with broader stakeholder engagement, could help identify potential "losers" from proposed projects and then work to ameliorate actual or perceived grievances (Gregory & Keeney, 1994; Kraft & Clary, 1991; D. Mazmanian & Morell, 1994; McAvoy, 1999; Munton, 1996). Flexible/adaptable decision-making could also be used to resolve stakeholder disagreements by outlining and visualizing multiple pathways that could lead to a mutually desired future (Haasnoot et al., 2013, 2019).

Breaking ground on a project that is judged by technocratic agencies to be feasible and economically beneficial may not always be desirable. Coastal adaptation works will not solve all problems and they are just one option from a spectrum of possible responses (e.g., protection, accommodation, retreat, advance; M. Oppenheimer et al., in press). Coastal adaptation works may lead to undesirable outcomes not recognized in their analyses such as being maladaptive (Barnett & O'Neill, 2010), inflexible (Arthur, 1989; Corvellec et al., 2013; Markolf et al., 2018; Payo et al., 2016), environmentally harmful (Orton et al., 2019; Swanson et al., 2012), or causing environmental injustices (Adger et al., 2006; Liao et al., 2019; Shi et al., 2016). For these reasons, knowing why projects fail is also useful for those who wish for a particular project to fail. Rather than thinking of protection strategies that focus on a single, critical threshold (e.g., 100-yr flood; Rasmussen et al., 2020), a more diverse suite could be used, such as those that are redundant, "safe-to-fail" (Kim et al., 2017), more affordable, combine natural and built infrastructure (Sutton-Grier et al., 2015), and more modular/flexible. These characteristics are the foundation of "resilience"-based approaches (Linkov et al., 2014; National Research Council, 2012; Park et al., 2013; Woods, 2015).

While our review emphasizes the importance of considering political complexities when pursuing adaptation works, it stops short of detailing specific mechanisms that may be necessary to generate effective policy recommendations. Future research could uncover these.

For example, examining historical case studies of controversial public works proposals could further open up the “black box” of politics and allow for identification of causal processes (Biesbroek et al., 2014; Elmore, 1979; A. M. Wellstead et al., 2013). Such an approach may be more likely to yield practical advice to policy makers on how to intervene, overcome implementation barriers, and obtain favorable outcomes and could also contribute to building political theory. This includes examining how political forces affect decisions (i.e., political economy). Examples of potential case studies include storm surge barriers and other public works that address societal risks (e.g., renewable energy, drinking water availability, and public transit), earthquake building codes and warning systems, and pandemic planning and response (e.g., COVID-19).

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Data Availability Statement

Data were not used, nor created for this research.

Figures

Figure 1. The completed Fox Point Hurricane Barrier in March 1966 (Providence, Rhode Island). Photo taken by the New England Division of the U.S. Army Corps of Engineers (Waltham, Massachusetts).

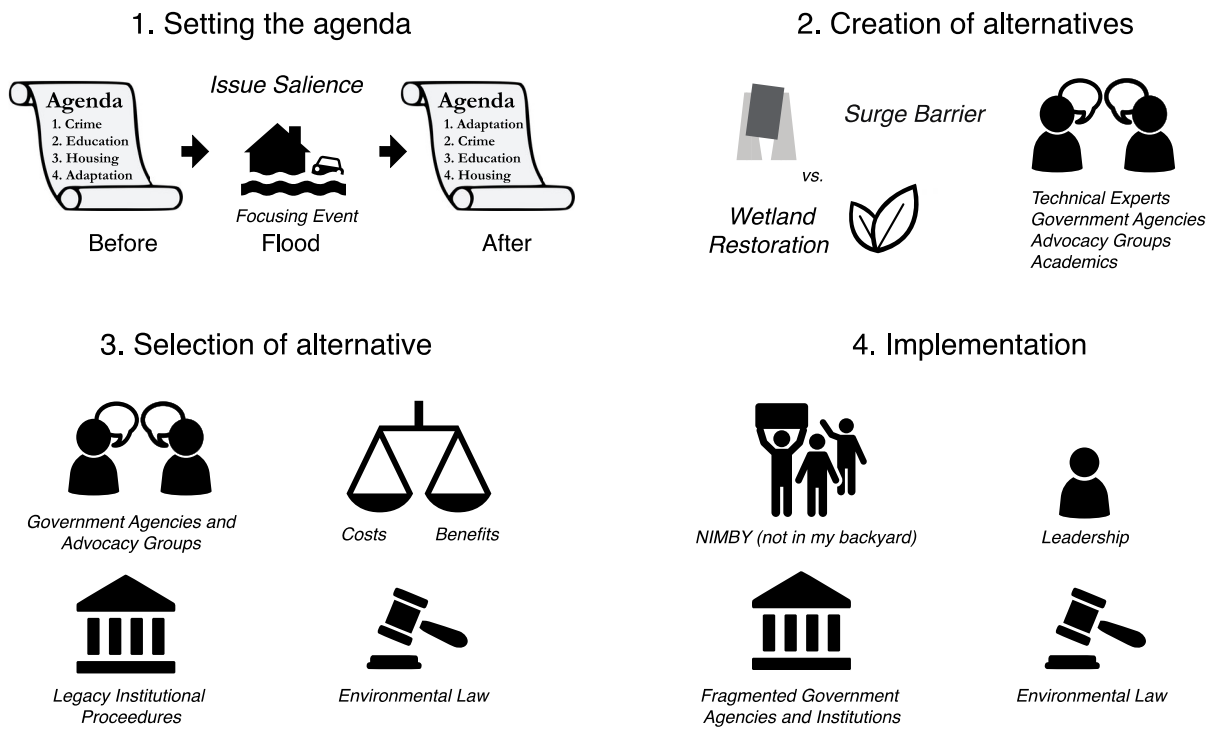

Figure 2. The process leading up to breaking ground on an adaptation works project organized into four different steps: 1) setting the agenda (Section 2), creating alternatives (Section 3.1), selecting from alternatives (Section 3.2), and implementation (Section 4).

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