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Research Article

Managing Climate Risks and Adaptation in Coastal Communities: How to Provide Information

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Abstract

In recent years, climate adaptation has gained significant attention from policymakers and public managers. In the U.S., states play a crucial role in developing coastal management policies, initiatives, and programs to reduce climate risks and enhance protection against extreme weather. Despite various approaches, few studies have examined information provision tools for coastal hazard mitigation and climate adaptation. As a result, there is limited knowledge about effective adaptation tools with low transaction costs. Using the StormSmart Coasts program as a case study, this research explores information-based climate adaptation and the components needed for a successful information-sharing platform. Established by the Massachusetts Office of Coastal Zone Management in 2008, StormSmart Coasts is a web-based program offering practical information for hazard mitigation to local decision-makers and communities. The study identifies three key features of an effective tool: providing tailored information to different stakeholders, serving as an outreach tool, and connecting with diverse stakeholders, including local managers and homeowners. The findings suggest that a well-designed information-sharing tool can enhance adaptive capacity and improve climate change preparedness in coastal communities.

Keywords

Climate risks, Climate Adaptation, Coastal Communities, Information-Based Adaptation Policy, Coastal Hazards Mitigation

1. Introduction

Building resilience in coastal communities is a critical climate policy agenda item across different levels of government. Resilience is the capacity of linked social-ecological systems to absorb recurrent disturbances to retain essential structures and processes [1]. With the trend of increasing natural disasters, scholars have focused on climate adaptation plans and activities for coastal communities [1, 2, 4, 5, 7, 14]. Prior studies have explored the significance of addressing climate risks through coastal planning and management [3, 4]. Others have identified favored adaptation tools, strategies, and technologies in coastal communities [11, 7, 14, 21, 22]. However, three gaps were identified in existing literature.

First, scholars in climate adaptation have focused on adaptive policy options [11, 14], with little regard to their effectiveness, measures, and transaction costs. Without such information, local decision makers tend to prioritize the implementation of coastal engineering works. They are often strongly supported by citizens, but typically do not address

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negative ecological impacts adequately [37]. Among adaptive options, large-scale engineering works are largely favored, but often incur high short-term costs and are maladaptive in the long-term [14]. Yet, knowledge enhancement tools with traditional coastal adaptation management methods could lower societal adaptation costs, while increasing the adaptive capacity of coastal regions.

Second, information about problems, solutions, and their implications facilitate the process of planned adaptation [28]. Prior studies acknowledge the significance of planning guidance, contextualized climate information, and best practice exchanges in developing local adaptation plans [12, 43]. However, one question still remains: what is a knowledge sharing platform format that enhances the use of information and promotes climate adaptation practices? An effective information provision tool may not simply store information. The tool will share information with varied stakeholders in an interactive, dynamic way to foster information use.

Lastly, climate adaptation policy coordination between upper and lower-level governments has not been well understood in prior literature. Adaptation requires local planning and implementation, and strong leadership [26]. Support from higher scales of governance would facilitate adaptive practices [38, 39]. In the U.S. climate policy context, prior studies recognize the state governments' leadership in crafting climate mitigation policies. However, less is known about their leadership in adaptation, which guides local governments' programs and policies.

This study fills these research gaps by focusing on an information-based climate adaptation approach in the U.S. coastal communities. The intention is to provide a comprehensive understanding of information-sharing tools. These tools have the potential to promote adaptation practices in coastal communities and maximize the benefits of investments in adaptation. Designing effective information guidance tools would be pivotal to scaling-up local adaptation planning, while minimizing data use transaction costs.

In the next section, this article will outline common coastal climate adaptation strategies and focus on information sharing as a policy tool that enables climate adaptation planning. The subsequent section discusses the three categories of information-based tools for planning adaptive strategies. Then an integrative framework is introduced encompassing 'Data and Information Provision,' 'Process Guidance,' and 'Knowledge Sharing' for effective information delivery. Lastly, the StormSmart Coasts program is presented to illustrate the application of integrative knowledge sharing framework and multi-level cooperative governance system. StormSmart Coasts is the pioneering coastal land management program created by the Massachusetts Office of Coastal Zone Management in 2008. The state-level initiative has grown as a national information network and supports storm management programs in eleven coastal states[1]. This study offers valuable insights into a web-based knowledge-sharing tool that facilitates the use of information across adaptive stages. Thereby, coastal communities could be empowered to reduce risks associated with climate hazards effectively.

2. Climate Adaptation Strategies in Coastal Areas

Climate change will continue to raise sea levels around the world, as the atmosphere warms and glaciers melt at an increasingly alarming pace [36]. According to the latest Intergovernmental Panel on Climate Change (IPCC) assessment report, the ice melt rate has been substantially increasing, contributing to sea level rise [19]. In 2022, global mean sea level was 4 inches above 1993 levels, making it the highest annual average in the satellite record (1993-present) [41].

Sea level rise in the U.S. is of great concern. The scenario projections of relative sea level along the U.S. coastline are about 0.6–2.2 meters (2–7.2 feet) in 2100 and 0.8–3.9 meters (2.6–12.8 feet) in 2150, relative to sea level in 2000 [36]. This would cause at least 2 feet increase in sea level and heightened coastal flooding risks, especially along parts of the East Coast. Given the projected scenarios, states need to develop developed coastal floods management programs. For instance, according to the earlier version of sea level rise projection model outcome, Massachusetts was assumed to have a one-to-three-foot rise over the next century in its coastal planning recommendations [23, 34]. The impacts of sea level rise are found across ecological, social, and economic dimensions. Rising seas inundate and drown existing wetlands, erode coastal beaches and barrier islands, and threaten species that live in these vulnerable habitats [30]. Coastal communities will thus face more frequent climate risks of hurricanes, storm surge, and tidal flooding. Flooding from high tides will likely occur more often and cause disruption, particularly on the East Coast and Gulf Coast [40]. Government disaster management costs (e.g., emergency response and rebuilding infrastructure) will then keep increasing, highlighting the importance of planned climate adaptation [34].

In this vein, climate adaptation strategies for coastal communities have been identified in several ways. The first approach follows the three widely recognized adaptive strategies of *protect*, *accommodate*, and *retreat* [17, 33]. To *protect* vulnerable coastal areas from inundation and sea level rise, the measures such as hard defense systems (e.g., seawalls, revetments), soft defenses (e.g., beach nourishment, dune restoration), and living shorelines (e.g., reefs, marshes) were identified [14]. *Accommodation* measures such as changes to building codes, increased setback requirements, hazard insurance, improved drainage, and emergency evacuation plans. Coastal *retreat* refers to planned or managed withdrawal from hazard-prone areas of the coast [7]. It involves relocating or abandoning high-risk area assets, preventing coastal devel-

1 Alabama, Connecticut, Delaware, Florida, Louisiana, Massachusetts, Mississippi, New Jersey, New Hampshire, Rhode Island, and Texas participate in StormSmart Coasts program [25].

opment, and allowing development that will be abandoned if necessary [7].

Another approach of categorization uses regulatory or non-regulatory requirements of climate adaptation tools. For instance, zoning, setbacks, and building code updates, are categorized as regulatory tools favored by local governments. Zone management programs for climate adaptation are considered to be non-regulatory planning tools [11, 7].

While establishing adaptation tools could promote climate adaptation practices in coastal areas, there are two limitations to the current discussion. First, more attention has been given to engineering-based regulatory tools and land use and development controls. While they can be powerful coastal resilience tools, equally important is 'comprehensive planning' as the first step. Second, adaptation is often local [7], therefore local planning managers need to judge the appropriateness and applicability of the adaptation options. As such, states must adopt policy tools that teach local managers about climate vulnerability and support informed decision-making. Local managers' capacity to adapt to coastal hazards will be contingent upon knowledge transfer and shared information.

Comprehensive process guidance, data and information provision on climate impacts and vulnerability, and knowledge sharing would enhance coastal climate adaptation [15]. Local climate adaptation is oftentimes hindered by inadequate information and insufficient financial and technical assistance from state or federal government [5, 39]. Effective adaptation tools need to assist users in the procedure of adaptation planning [29]. They can serve to raise awareness, identify vulnerability and risk, help assess and select adaptation options, and evaluate adaptation success [29].

3. Information-Based Adaptation Tools

Specific adaptation strategies are sorted by strengths and weaknesses, along with the costs and constraints of implementation [13]. In general, information-based solutions in public policy can have impacts on people's behavior. Information-based solutions for coastal communities enhance people's coastal hazard awareness and lead to ideas about how to adapt to climate change. For instance, information-based tools can change public perception of the value of ecosystems providing environmental benefits such as reduced coastal erosion so that the public can more support climate adaptation plans including soft defense mechanisms, rather than engineering-based flood control systems [7, 10, 27]. During major disasters, information-based tools could also assist local officials in decision-making regarding building damage assessment and risk minimization. It should be noted that despite these benefits, information-based adaptation tools are less expensive when compared to regulatory adaptation approaches such as relocation, retreat, and financing [7].

However, if poorly designed, information-based solutions can be ineffective and highly costly. For instance, the Chesapeake Bay monitoring project provides water quality information to stakeholders who are responsible for land-based nutrient inputs. The project has proven to be quite expensive and has done little to the overall improvement of the bay [20]. Steps should be taken to avoid creating meaningless resources that would not be used to create real change. In tight state budgets, tools with high return on investment are critical.

In the context of climate adaptation, information will be critical in the planning and subsequent implementation of adaptation actions. It is suggested that adaptation practices can be fostered through learning by doing stakeholder engagement [5]. Examples include 'listening sessions,' and 'sharing best practices,' which go beyond the simple presentation of science-based climate risk information [5].

Currently, there are different types of information provision tools that are available for climate adaptation. Information-based tools for climate adaptation planning can be classified in the following three ways:

1) Process guidance,
2) Data and information generation and provision, and
3) Knowledge sharing tools [15].

Each type of tool has its own uses and advantages. Process guidance tools guide planning managers through identifying, gathering, and analyzing relevant data and information. They help identify climate risks, assess and analyze strategies, and evaluate options to integrate into land use and development activities. Data and information provision tools generate primary climate variables (e.g., rainfall trends) and secondary information on climate impact, such as flood maps. Knowledge-sharing tools are platforms and networks offering stakeholders virtual space to access information and experiences about climate risks and adaptation. Data and information generation tool outputs can often be used as inputs into process guidance tools and vice versa. Table 1 lists the various kinds of information available within each information tool.

Table 1. *Three categories of information-based tools for planning adaptive strategies in response to climate risks.*

Data and Information Provision	Process Guidance	Knowledge Sharing
1) Primary climate info: a. Current temperature and rainfall data and maps b. Future climate projections	1) Communication tools for increased awareness on climate risks 2) Problem identification tools (climate risk screening)	Web-based platforms, offering access to: 1) Relevant news (e.g., media stories, recent discussion meetings for climate adaptation) 2) Scientific, policy, project documents (e.g.,

Data and Information Provision	Process Guidance	Knowledge Sharing
2) Secondary climate information: impact models, flood maps 3) Vulnerability information: socio-economic data (e.g., demographic information, vulnerability information across varied sectors)	3) Assessment tools 4) Implementation tools 5) Monitoring and evaluation tools	journal articles, case studies, reports) 3) Personal observations and experiences (e.g., informal blogs) 4) Professional networks 5) Data and information provision tools 6) Process guidance tools

*This table is modified from [11].

Dynamic knowledge sharing platforms can integrate the elements of information and data provision and process guidance, as displayed in Figure 1. Such an integrative knowledge sharing platform may disseminate more comprehensive information than single-faceted methods. That means an effective knowledge enhancement tool for climate adaptation can enable decision-makers to go beyond acquiring climate scientific information. They would also be equipped to identify climate risks and develop risk management strategies using data-driven tools. It also fosters professional networks to gain valuable, actionable information in a more informal, personal way.

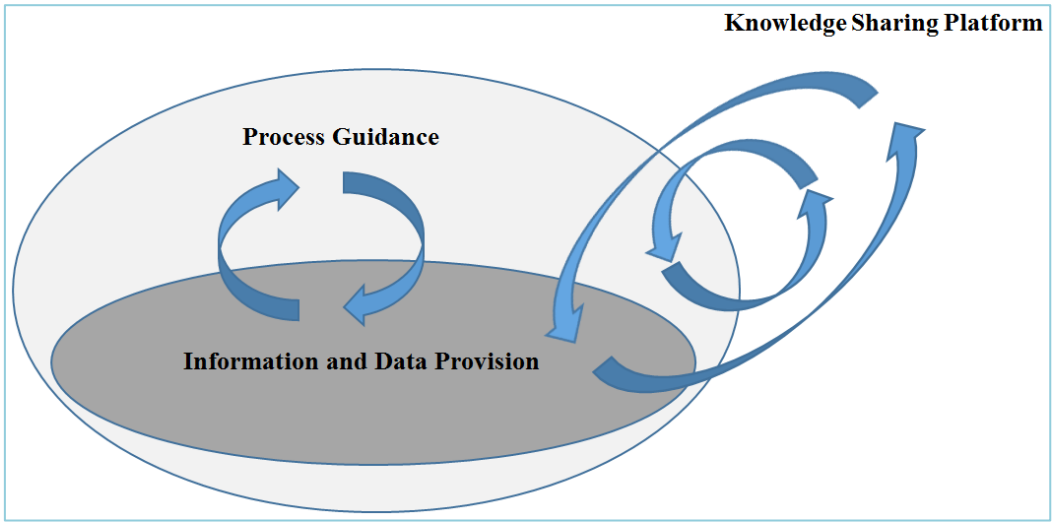

Figure 1. *An integrative model of information and data provision, process-guidance, and knowledge sharing platform.*

4. Coastal Adaptation to Climate Change in the U.S.

State-level climate adaptation action has focused on developing adaptation plans and providing incentives for lower governance-scale adaptation [28]. There are various approaches seen in state governments. Some states integrate adaptive measures into current planning processes, while others develop new practices to reduce natural disaster-based climate vulnerability [10, 27, 28, 32]. Relying on states' financial and technical assistance, local governments have taken responsibility for local planning and development assessment. Municipalities are making basic land-use decisions for the protection of the health, safety, and welfare of their residents.

In most cases, coastal states have developed Coastal Zone Management Programs (CZMP)[2]. CZMPs are voluntary federal-state partnerships that protect, restore, and responsibly develop coastal communities. They practice adaptation to address coastal hazards. According to the GAO's CZMP performance review study [42], states received around 50 million dollars in grants under this program. The funds supported activities that minimized coastal hazard risks such as

2. CZMP is governed by Coastal Zone Management Act (CZMA), which was enacted in 1972. The National Oceanic and Atmospheric Administration (NOAA) is responsible for implementing the act and administers the CZMP. NOAA also administers the National Estuarine Research Reserve System—a network of protected areas that provide research, education, and resource stewardship to help communities address coastal resource issues—and the Coastal and Estuarine Land Conservation Program, a funding program which provides matching funds to state and local governments to purchase priority coastal and estuarine lands of ecological, conservation, recreational, and historical importance.

storms, and improved hazard awareness and understanding from 2008-2013. CZMP funds dedicated to coastal hazards increased by around 130 percent (7 percent in 2008 to 16 percent in 2013). Since the program requires matching funds, states are now investing more in climate change adaptation, resulting in resilience of coastal communities [42].

The content analysis of coastal states' CZMPs found that generally, coastal states' CZM programs include five different types of adaptation planning and assistance programs. The programs focus on:

1) Technical assistance for adaptation planning,
2) Financial assistance through grants for local adaptation planning,
3) Process-based adaptation guidance,
4) Information and data provision (e.g., climate vulnerability modeling and mapping, adaptation options, etc.), and
5) Knowledge sharing platforms (mobile apps, websites, web-based information-sharing hub).

Most east coast states [3] have vulnerability assessment mapping and modeling tools to evaluate coastal hazard risks such as storm surge [31].

In addition, states have developed their own programs to protect the lives of their residents and address coastal erosion. With respect to coastal area protection, the most popular approach used is leveraging the building permitting process. Permits can regulate the construction of engineering structures that are vulnerable to sea-level rise. For instance, California requires builders to apply for shorefront development permits to ensure that sea level-related risks are considered in the project plans [6]. In another approach, states have implemented regulatory mandates for setbacks (distances between a structure and the shoreline) to allow structures to be moved further from the current shoreline. In 2009, North Carolina began the setback mandate to reduce damage from strong storms. The setback also considers the reduction of potential damage from sea level rise by calculating local erosion rates. As another example, the Maine's Sand Dune Rules require structures greater than 2,500 square feet to be set back at a distance, considering two feet of sea level rise over the next 100 years [11]. Lastly, states implement living shorelines initiatives to employ natural habitat elements to protect shorelines from erosion. In Virginia, the living shoreline initiative establishes oyster reefs and plants vegetation such as marsh and dune grass. It also uses a combination of vegetation and strategically places low-profile barriers in order to replace armoring shorelines with hard structures such as bulkheads (e.g., rocks, woods) [44].

Some states have been very active in conveying climate risk-related information. The provided information varies among the states. Some other states present climate scientific information that is mostly from federal government such as National Oceanic and Atmospheric Administration (NOAA). In other cases, states develop their own region-specific vulnerability assessment data. They can make the information available with adaptation options for hedging climate risks at the local level. For instance, the U.S. Army Corps of Engineers, and NY Department of Environmental Conservation collect coastal hazard information with climate vulnerability data [35]. Detailed information is often compiled into booklets for public consumption. In Hawaii and Maine, homeowner handbooks were developed to empower residents to prepare for natural disasters using the listed strategies. However, it seems that information on climate risks in coastal areas has not been effectively communicated. Information provision by states has not been often unknown to local public managers, policy makers, and residents, while information has not been easily accessible.

Taking a pioneering effort, Massachusetts (MA) adopted the StormSmart Coasts Program as the first web-based information hub for coastal management. It includes climate change data, technical and financial assistance, and an outreach component. The idea is to promote adaptive capacity in coastal communities while minimizing adaptation costs. In the following section, StormSmart Coasts will be discussed as a case of an effective information sharing tool, as well as the forerunner of knowledge sharing hubs for local planning managers and the public. The tool includes process-based guidance and climate vulnerability and adaptation information. It also promotes interactive and dynamic knowledge sharing. It intends to facilitate stakeholder engagement in the local decision-making process.

5. Stormsmart Coasts Program in Massachusetts

With more than 1,500 miles of coastline, Massachusetts is highly vulnerable to the destructive impacts of hurricanes and blizzards. Each season, it experiences storm damage even from minor storms. In 2006, the Governor and state legislature requested the creation of a Coastal Hazards Commission (CHC) to address these issues. The Massachusetts Office of Coastal Zone Management (CZM) took on the task. The CHC formed five working groups, including experts in coastal hazards and management from government, academia, and the private sector. They focused on coastal hazards information, policies, planning and regulations, structural and nonstructural coastal protection, and public coastal infrastructure. After several meetings and the solicitation of public comments, the CHC approved 29 coastal hazards management recommendations and implementation plans [24]. A Coastal Hazards Information Portal was suggested as one of the CHC's recommendations.

Given the recommendation, the Massachusetts Office of CZM started the StormSmart Coasts program in 2008 [25]. It

3. The states for content analysis include Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New Jersey, New York, Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Louisiana, Texas, Oregon, Washington, Alaska, and Hawaii.

has gone through changes since then and is active today. StormSmart Coasts is a way to connect local officials with resources to address sea-level rise, flooding, and coastal erosion. The tool contains resources, websites, and data-sharing systems that distribute coastal hazards-related information and management options. It focuses on local lawmakers and officials, responsible for protecting their communities. However, it also educates and connects local stakeholders including property and homeowners. Three sub-components of knowledge sharing are present. StormSmarts Communities includes tools for local planning managers. StormSmart Properties provide tools for homeowners. Finally, Vulnerability Assessment Tools helps users visualize shoreline change data and coastal inundation due to sea level rise and storms [25].

As an information hub, StormSmart Coasts program is effective in three ways. First, it conveys *customized* information to different stakeholders. One facet of the web-based information tool serves as a delivery channel of general climate science and climate weather information. Another provides user-specific administrative, financial and legal information. A user can choose the relevant local board or commissions in coastal management and their potential roles in making changes. This is key as users receive role-specific resources and instructions to begin to address coastal zone management in their communities. It can empower officials who otherwise do not have the full skillset or understanding to carry out such a project. Among the topics addressed are 'No Adverse Impact Floodplain Management'[4], inventories of seawalls and other coastal structures, funding for mitigation and other activities, and publications. It also informs coastal property owners about applicable regulations, agency contacts, common permits, and recommendations for StormSmart building techniques.

Second, it focuses on *outreach* to inform potential users of the availability of new data and tools. In doing so, adaptation guidance has been provided to local planning managers with a hands-on work format. Local planning managers have received much-needed technical assistance throughout the entire adaptation planning process. In 2010 after two years of launching the program, seven communities were engaged to develop adaptation plans with the state under the StormSmart Communities initiative [16]. The pilot projects have been published on the StormSmart Coasts website. For instance, Hull, MA was able to use a mapping tool to visualize potential local flooding scenarios from sea-level rise. It resulted in an incentive program to raise buildings a few feet above regulation in return for building permit credits. Differently, in Oak Bluffs, MA, regulations were changed to better reflect construction allowances in designated areas of the flood plain. The solution reflected a balance between limiting development and making revenue from new construction projects [16]. With more clearly defined land usage laws, local officials should be able to better manage lands in the flood plain.

Third, it fosters *vertical and horizontal connections* among coastal planning managers and thereby facilitates knowledge sharing. The successful launch of the Massachusetts StormSmart Coasts initiative in 2008 led to the development of a national network in 2009. A growing partnership of coastal decision makers is supported by NOAA's Coastal Services Center, Northeast Regional Ocean Council, Gulf of Mexico Alliance, and others. They are known as the StormSmart Coasts Network. The StormSmart Coasts National Network website provides local decision makers with information on erosion, flooding, storms, and sea level rise. Also, the website serves as a platform to help them connect and collaborate.

In addition, StormSmart Coasts encourages cost-effective adaptive practices by linking different informative resources. For instance, the tool has highlighted the Federal Emergency Management Agency (FEMA)'s National Flood Insurance Program (NFIP) and Flood Insurance Rate Maps (FIRMs). NFIP encourages communities to adopt and enforce floodplain management regulations to mitigate future flood damage, and FIRMs show the estimated extent of flooding during a hypothetical 100-year storm, also called a 1% storm, which is a storm that has an estimated 1% chance of being equaled or exceeded during any given year. In introducing FIRMs and the way to interpret maps, StormSmart Coasts encourages users to determine the spatial extent and magnitude of predicted flooding in a major coastal storm. Homeowners and consultants can then design the safest possible coastal project while public officials can evaluate these projects to ensure they are designed to minimize storm damage, protect public safety, and reduce the financial burden on individuals and municipalities from losses due to coastal storms [9]. The website serves as a vehicle to connect communities to federal programs that already exist but have perhaps been underutilized.

6. Perspectives on the Adaptive Efficacy of StormSmart Coasts

StormSmart Coasts is a comprehensive information sharing tool because it provides technical information and lays out all the possible options to deal with sea-level rise. It also involves ways to engage with different stakeholders and promotes the use of information by providing connection opportunities for real-world information.

It is cost-effective in that it is instrumental in facilitating the adoption of adaptive options at the local level. As illustrated by CZM's StormSmart Coasts pilot project with the town of Hull, the three-dimensional visualizations of flood events and sea level rise promoted the town's adaptive capacity, while minimizing future adaptation costs. There are costs involved in evaluating the current shoreline situation in order to make informed decisions about how to proceed. Although these pilot

4 The 'No Adverse Impact' approach is based on the idea that protecting one set of stakeholders from flooding should not, in turn, leave another population more susceptible to flooding. It includes community-based decision making and contribution. The website includes ways that NAI approaches can help their communities to get stakeholders on board.

projects have upfront costs to gather the information and develop a plan, they serve to help prevent the large costs associated with property damage and habitat loss [25].

StormSmart Coasts program could also serve to change people's perspective on the value of natural shoreline buffers and thereby lead to increased wetland preservation and restoration efforts by residents. Basically, if people become better informed about how different coastal measures can affect their safety, then they will be more likely to hold their local officials accountable to community changes.

Despite its great influential potential, the StormSmart Coasts program has some limitations in terms of its accessibility. A web-based tool is limited to those who have access to technology and education by which to operate it. In this case, older generations would be disadvantaged. Ease of usability would prove important to this population in terms of how accessible it would be.

In addition, the web-based information tool is only offered in English at present. This excludes those who do not understand English well from having the same access to resources. For instance, in a case study of sea level rise preparedness in East Boston and Everett, meaningful community participation was accomplished by providing a translator for Spanish-speaking residents [8]. The website could surely be offered in other languages that are prevalent in the coastal communities of Massachusetts.

7. Discussion and Conclusion

The intensifying extreme weather events and their impacts on socio-ecological systems across the globe and the nation underscore the imminent need to adopt and implement climate change adaptation measures. Coastal areas are particularly vulnerable and people living in these areas are facing substantial climate hazards risks, as approximately 23% of the global population and 39% of the U.S. population lives in these areas [2, 30].

Prior studies have identified varied climate adaptation options that are regulatory or non-regulatory. The options can help protect vulnerable coastal areas from inundation and sea-level rise, and have included updated building codes, urban design standards, and elevated floor and increased setback requirement to accommodate the sea-level rise and storm surge. However, little attention has been paid to information-based solutions that may greatly facilitate adaptation planning processes, although lack of information and adequate form of knowledge sharing hinders local governments from adapting coastal hazards [39].

This study asks the following fundamental questions: which type of adaptation tools would be effective in consideration of promoting greater adaptive capacity with low transaction costs? Which would be a desirable information sharing platform that can enhance the actual use of information gathered? Given that climate adaptation is local, contains scientific and technical aspects of climate vulnerability data, and requires decision-making processes including varied stakeholders, a more interactive, participatory information sharing channel would help information reach its intended audience and increase adaptive efficiency in coastal communities.

The case of StormSmart Coasts illustrates that the program includes three components that focus on process guidance, data and information provision, and knowledge sharing. It effectively provides tailored information to different stakeholders throughout an entire process of adaptation planning, outreaches with potential users of climate information, and connects with varied stakeholders including local managers and homeowners. These three features can be translated into objective measures of what makes for a successful information-sharing tool.

While local governments have statutory rights to plan local adaptation plans and implement them, leadership from higher-governance level is essential to encourage more responsive adaptive actions in the face of coastal hazards. States can play a central role in providing information, technical assistance, and financial incentives in support of local governments' coastal zone management and linking multiple governance levels.

In conclusion, the utilization of coastal climate change information is not guaranteed. An integrative model for information dissemination, which includes data provision, process guidance, and knowledge sharing, would enhance local climate adaptation planning and strengthen the resilience of coastal communities. This approach could help minimize adaptation costs. Future research would benefit from empirical models that assess the effectiveness of a more dynamic, interactive, and comprehensive knowledge-sharing tool that combines scientific and socio-economic information and data. It can also explore how the coordination between local, state, and federal governments via information sharing has lowered the impacts of floods and storms on coastal communities.

Abbreviations

CHC	Coastal Hazards Commission
CZM	Coastal Zone Management
CZMP	Coastal Zone Management Programs
FEMA	Federal Emergency Management Agency
NFIP	National Flood Insurance Program
FIRM	Flood Insurance Rate Map
IPCC	Intergovernmental Panel on Climate Change

Author Contributions

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Julie Ross: Data curation, Formal Analysis, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

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