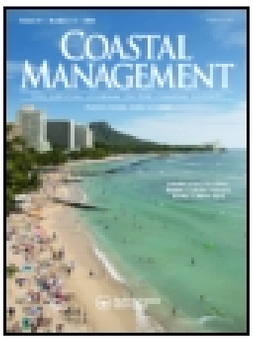

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Climate Change Adaptation and Extreme Weather in the Small-Scale Fisheries of Dominica

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ABSTRACT

Globally, changes in the intensity, severity and frequency of storms threaten potentially catastrophic impacts on fisheries. These threats present a significant challenge to Small Island Developing States because of the important contribution of fisheries to multiple aspects of coastal communities' wellbeing, including food security, coastal economies, and social and cultural identities. Supporting the adaptive response of fisheries to storm events is therefore a priority, yet efforts to enhance adaptive capacity are limited by knowledge gaps relating to fishing communities' needs and behavior. Tropical Storm Erika (2015) and Hurricane Maria (2017) were the most destructive disasters in Dominica since Hurricane David in 1979. We present findings of a scoping visit to Dominica which examined the impacts of these extreme weather events in coastal communities. Using a framework outlining five key domains of adaptive capacity we identify insights related to the diverse experiences of fishing communities, and the individual, household and institutional capacities that have implications for resilience to future shocks. Understanding the experience of Dominica can inform the development of targeted adaptive capacity-building strategies nationally and in other contexts.

KEYWORDS

adaptive capacity; Caribbean; climate change; extreme weather; small-scale fisheries

Introduction

Globally, the fisheries sectors of Small Island Developing States (SIDS) have been identified as particularly vulnerable to climate change and climate variability (Monnereau et al. 2017, 2015). Climate impacts affecting fisheries include slow changes such as ocean warming, acidification and sea level rise, which contribute to shifts in the distribution of important target species, threaten degradation of habitats such as coral reefs, and impact coastal communities (Barange et al. 2014; Hoegh-Guldberg et al. 2007; Nurse 2011; Sumaila et al. 2011). In contrast, greater frequency

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or intensity of severe storms is a climate stressor with more immediate and potentially disastrous impacts in the absence of adaptation. The impacts of extreme weather events have received less attention than other impacts of climate change in fisheries vulnerability assessments, partly because the science around changes in storminess remains very uncertain (Sainsbury et al. 2018). However, future changes in the intensity, severity and frequency of storms could threaten fisheries through disruption of fishing and fish processing activity; damage to fishing vessels, gear, and coastal infrastructure including dwellings; impacts on the safety of fishers at sea and fish-workers on land; and jeopardizing the wellbeing of fishing households and their entire coastal communities.

In Latin America and the Caribbean, climate change (taken henceforth to include climate variability) threatens the livelihoods of an estimated two million people who are directly or indirectly linked to small-scale fisheries (Chuenpagdee, Barragán-Paladines, and Salas 2018). The Intergovernmental Panel on Climate Change (IPCC) has concluded that the frequency of intense tropical storms in the North Atlantic Basin has increased since the 1970s (IPCC, 2014, IPCC 2013). In 2017 North Atlantic hurricanes devastated vulnerable Caribbean fisheries, particularly in the islands of Dominica and Barbuda. These threats present a significant challenge to Caribbean SIDS because of the important contribution of fisheries to multiple aspects of coastal communities' wellbeing, including food security, coastal economies, and social and cultural identities. Small-scale fisheries often provide a safety net when other economic activities are temporarily impacted or in decline (Béné et al. 2016), and fisheries can be one of the first sectors to bounce back following a disaster. In Dominica, fisheries proved to be important for food security in the immediate aftermath of Hurricane Maria in 2017 (Pinnegar et al. 2019). Supporting the adaptive response of fisheries to storm events is therefore instrumental in aiding wider national recovery.

The ability to anticipate and respond to change, to cope with or adapt to the threat, and to respond to new opportunities is encapsulated by the latent characteristic of adaptive capacity (Smit and Wandel 2006). Along with exposure (e.g., to storms) and sensitivity (the degree to which a system is affected positively or negatively), adaptive capacity is an important component of vulnerability to climate change (IPCC 2001). In light of the climate-induced disturbances that are already impacting coastal communities and the resources they depend on, the need to build adaptive capacity to cope with future changes is expected to escalate (Cinner et al. 2018). A growing body of research on adaptive capacity has emerged, including assessments of adaptive capacity in fisheries sectors undertaken as part of climate vulnerability assessments at national or community scales (Allison et al. 2009; Cinner et al. 2012; Monnereau et al. 2017; Pinnegar et al. 2019). However, to date a narrower view of adaptive capacity has been applied in practice compared to policies and plans (Watkiss, Ventura, and Poulain 2019), often focusing on assets or technical issues such as information provision (Tanner and Mitchell 2009), but failing to recognize social factors that constrain adaptation (Coulthard 2008; Jones and Boyd 2011). Recent work has highlighted that, as well as assets, the domains of learning, agency, flexibility and social organization are important if resources are to be translated into effective adaptive action (Cinner et al. 2018).

The impacts of extreme weather events on coastal communities represent an important intersection between climate change adaptation and disaster risk management (especially response and recovery). Large sections of society remain vulnerable to climate-related shocks despite a long history of disaster management, and there is a need to improve adaptation processes (Adger et al., 2005). At a local level, adaptive capacity can be a useful entry point for understanding individual and community resilience to future shocks (Chelleri et al. 2015). However, whilst the actual practice of adaptation occurs largely at a local level (Coulthard 2008), effective adaptive action is determined not only by individual, household and community-level sources of adaptive capacity, but also by the effectiveness of institutions engaged in responding to change (Jones et al. 2010a). Disaster response and wider humanitarian and development efforts can either support or erode adaptive capacity. It is therefore important to consider how both institutional and individual responses to extreme events can enhance coastal communities' capacity to respond to climate change, and avoid undermining adaptive capacity to future shocks, yet empirical evidence addressing this question remains limited (Jones et al. 2010a).

The challenges of building climate resilience and adaptive capacity have been recognized by regional research and development institutions in the Caribbean, including the United Nations Food and Agriculture Organization (FAO) (McConney, Cox, et al. 2015). FAO has since implemented the Climate Change Adaptation of the Eastern Caribbean Fisheries Sector (CC4FISH) Project funded by the Global Environment Facility. CC4FISH seeks to increase resilience and reduce vulnerability to climate change impacts in the Eastern Caribbean fisheries sector through the introduction of fisheries adaptation measures and capacity building for fisherfolk. Financial solutions to climate change impacts that seek to increase the resilience of fisheries are also being developed in the region through the Caribbean Catastrophe Risk Insurance Facility (CCRIF), with their first parametric fisheries insurance product launched in 2019 in Grenada and Saint Lucia (CCRIF SPC 2019). However, institutional responses (such as strengthening local organizations, building social capital and creating learning networks) intended to address perturbations in Eastern Caribbean fisheries remain limited by knowledge gaps relating to fishing communities' needs and behavior in relation to adaptive capacity (McConney, Cox, et al. 2015).

Understanding the sources of adaptive capacity that communities were able to draw upon to respond to past extreme events can help to identify priority areas for strengthening adaptive capacity and enhancing future resilience (Bussey et al. 2012). The Commonwealth of Dominica, which experienced the devastating impacts of Tropical Storm Erika in 2015 and Hurricane Maria in 2017, presents an ideal context to explore the key impacts, responses and sources of adaptive capacity in relation to extreme weather events. Acknowledging that important elements of adaptive capacity are not necessarily well reflected in the development of composite indicators (Lavoie et al. 2018; Pinnegar et al. 2019), and that composite indicators are not well suited to reflect the diversity of people's experience within the same fisheries, we take a qualitative approach to explore this case study. The aim of this paper is to develop an understanding of fishing communities' responses to storm disruption, and to understand how institutional interventions to the disaster shaped these responses. In doing so we seek to contribute

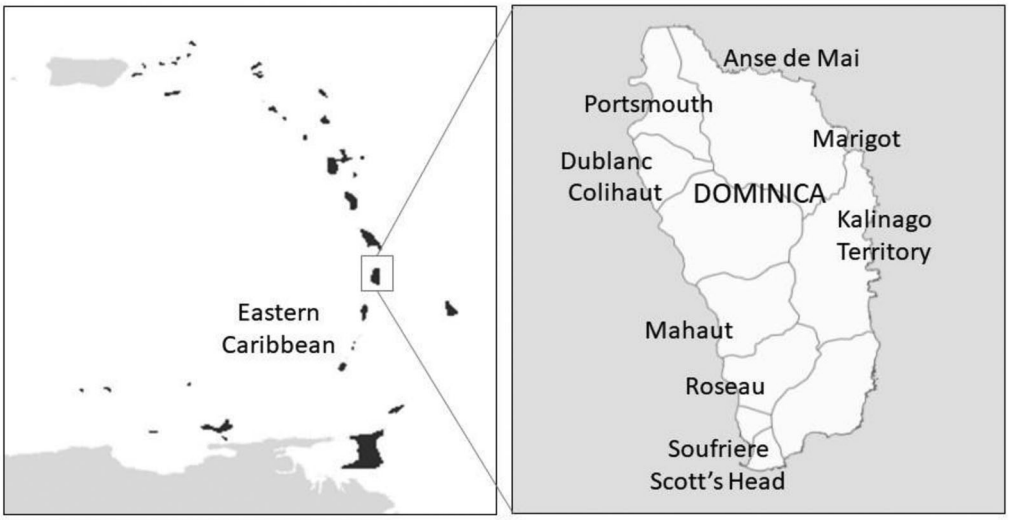

Figure 1. Location of Dominica in the Eastern Caribbean.
Source: Authors.

to an evidence base of community-embedded perspectives for informing greater attention to implementing effective adaptive capacity building by institutions in the region.

Methods

Study site

The Commonwealth of Dominica (hereafter Dominica) is the largest of the Eastern Caribbean Windward Islands (Figure 1). Dominica has a distinctive natural environment with steep topography and a narrow coastal shelf. The island typically experiences increased rainfall and changing wind patterns during the hurricane season from July-October. These conditions create vulnerability to a range of natural hazards, including tropical storms and hurricanes, intense rainfall and associated flooding and landslides, potential for storm surge and tsunamis, and risks related to volcanic and seismic activity (Benson et al. 2001). Due to the rugged topography of the island, the majority of major infrastructure and settlements are located in coastal areas, making them particularly vulnerable to severe storms and high winds. Most recently Hurricane Maria, a category 5 hurricane, hit the island in September 2017 causing damage equivalent to two years of GDP (King 2018). This was preceded by Tropical Storm Erika in 2015, which was less severe but also had a major impact on coastal communities.

Dominica is an upper middle income country, though it is among the poorest countries in the Eastern Caribbean (CoD 2018). Declines in other industries such as banana production have contributed to increasing dependence on fishing for consumption and income, and fish consumption is high at 26.4 kg/yr per capita (FAO 2018). Dominica's fisheries sector employs around 2200 people, including full and part-time fishers, fish vendors and ancillary workers (CoD 2017). The fishery is small-scale artisanal, with little of the catch exported. There are approximately 800 registered fishers operating

across 21 landings sites around the island, and approximately 440 of an estimated 650 fishing vessels are registered with the Fisheries Division (CoD 2017). Fishing vessels typically range from 5-10 meters in length and include traditional dugout canoes, wooden boats, and more modern fiberglass-reinforced vessels, usually using outboard engines. Fisheries target offshore pelagics, coastal pelagics, and reef-related or demersal species, using primarily hook and line or fish traps. Catches around offshore, anchored, surface fish aggregating devices (FADs) account for over two-thirds of landings (Defoe, Norris, and Fujii 2012 cited in Pinnegar et al. 2019).

The key landing ports are Marigot and Portsmouth, on the northeast and northwest of the island respectively, while the capital Roseau in southeast Dominica is the main administrative center for fisheries and home to the main fish market and processing facility. The fishery operating from Marigot includes a large proportion of close-knit indigenous fishers from the Kalinago Territory. Today most of their fishing boats, gear and methods are similar to those of other Dominicans, but they are said to generally have a higher catch per unit effort according to fisheries officers. Dominican fishing towns and villages tend to be well-defined geo-spatial and social communities due to the rugged geography of the island where local government is still practiced. Community-based resilience is an important aspect of the country's planning for sustainable development (CoD 2020).

In response to the vulnerability of the island to climate change and extreme weather, the Government of Dominica has made an ambitious pledge to become the world's first climate resilient nation as stated in the Government's National Resilience and Development Strategy (CoD 2018). Their Climate Resilience and Recovery Plan (CRRP), in preparation at the time of writing and published early in 2020 (CoD 2020), is intended to outline the conceptual thinking about the meaning of resilience in the Dominican context. The Climate Resilience Executing Agency of Dominica (CREAD), established in 2019 to cover all economic sectors and services, will operate within this policy, coordinating strategic initiatives to support the goal of making Dominica the world's first climate resilient nation (CoD 2018).

Approach

The findings presented in this paper are based on a qualitative scoping field study conducted in April 2019 in Dominica. The fieldwork comprised two components. First, field visits were undertaken to: i) three major fishing ports – Portsmouth, Marigot and Roseau; ii) smaller fishing communities of Anse de Mai, Scott's Head, Soufriere, Mahaut, Colihaut, Dublanc; and iii) the Kalinago Territory. These sites (Figure 1) provided diverse a mix of fisheries, fishing facilities and sizes of community. At each site informal interviews were opportunistically held with small groups of fishers, boat owners, fish vendors, other fish workers (collectively termed fisherfolk) and community members to understand experiences of Hurricane Maria in relation to the impacts of the hurricane on fishing practices and wider livelihoods, responses to the event, and perceptions relating to future resilience. Groups ranged from 1-8 people and were conducted face-to-face at landing or market sites, lasting approximately 20 minutes to an hour each. Topics covered fisherfolk's

experiences of and responses to Hurricane Maria, perceptions of institutional responses to the disasters, and views on what would support future resilience.

Second, informal interviews were undertaken with representatives of key organizations involved in disaster preparedness and response, natural resource management, community development, and climate resilience. Participants in discussions included representatives from: Office of Disaster Management, CREAD, Fisheries Division, Physical Planning Department, Dominica Bureau of Standards, World Bank Disaster Vulnerability Reduction Project (DVRP), United Nations Development Program, Red Cross Society, Global Environment Fund Small Grants Program, Community Development department, Soufriere-Scott's Head Marine Reserve (SSMR) Local Area Management Authority (LAMA), Rotary Club, National Focal Point for Japan Caribbean Climate Change Project, and Solid Waste Management Corporation. Interviews involved 1-2 representatives from each organization and typically lasted 30 minutes to an hour. They were conducted face-to-face, usually at the respondents' place of work. Topics covered included experiences of working with coastal communities in relation to preparation for and responses to disasters including Hurricane Maria, perceptions of Dominica's ambition to become the world's first climate resilient nation and what this means in practice, and discussion of ongoing work by each institution related to building resilience.

Access to respondents, especially to fisherfolk, was facilitated by a former head of the Government of Dominica's Fisheries Division who also shared local and expert knowledge gained over decades of work with the fishing industry in Dominica. The selection of institutions and communities for interviews was driven by the researchers to minimize any bias introduced by using a single gatekeeper. We were unable to arrange a convenient time to meet with the Chief Development Planner, but otherwise were able to meet all the institutions we had intended, therefore we consider the sample to be broadly representative of the institutions involved in disaster response and fisheries management in Dominica.

Detailed notes were taken in discussions with both fisherfolk and representatives of institutions, and later coded thematically to identify the elements of adaptive capacity that have been important in response to Hurricane Maria, including both those elements that have supported adaptive responses and those that could be enhanced to develop future resilience. The findings are broadly organized following the framework set out by Cinner et al. (2018) which identifies five key domains of adaptive capacity. These are: 1) the assets people draw on in times of need; 2) flexibility to change strategies; 3) the ability to organize and act collectively; 4) learning to recognize and respond to change; and 5) the agency to mobilize adaptive capacity and act in response to change. This framework focuses on individual, household and community level adaptive capacity, which we adopt while also drawing attention to the role of institutional responses within these adaptive capacity domains. Our coding was guided by the framework, while allowing other related issues to emerge. While there are other approaches to understanding adaptive capacity (e.g., Brooks and Adger 2004; Engle 2011; Jones et al. 2010b; Pahl-Wostl 2009), Cinner et al. (2018) paper reviews much of this literature and provides a broad framework in which to situate our exploratory findings.

Ethical approval for the study was obtained through the University of Exeter Research Ethics Committee. Prior to each meeting we explained the purpose of the scoping visit to respondents and the roles of the research team, which as well as academic research included involvement in regional UN Food and Agricultural Organization projects engaged with climate resilience and adaptation in Caribbean fisheries.

Results

All five domains of adaptive capacity were discussed by participants, highlighting the ways in which each domain was important (and for whom) in responding to Hurricane Maria, and areas in which resilience-building activity could seek to enhance adaptive capacity. These are summarized in Table 1 and discussed in the following sections.

Assets

Hurricane Maria impacted both private and public assets with differing levels of severity depending on the exposure and sensitivity of different parts of the coast especially to winds and waves. Fishing assets, such as boats and gears, were less severely impacted in the northern communities of Marigot and Portsmouth where infrastructure allowed fishers to haul boats up, compared to southern communities such as Soufriere and Scott's Head which had limited protective infrastructure and the main fisheries complex of Roseau where fishers reported that the majority of boats and gear were lost or damaged by heavy flooding. Where damage to individual fishing assets was limited, fishing activity resumed within weeks, yet remained restricted by dependence on shared damaged infrastructure and services (e.g., refrigerated storage and ice production). Fishers reported being restricted to short trips because of limited access to water, electricity, ice and fuel. Similarly, fish vendors were impacted by damage to shared infrastructure including the fisheries complex in Roseau, as well as individually and collectively owned assets such as cutting boards and insulated fish boxes. Vendors played an important role in recovery of the market chain by traveling to lesser-impacted fishing communities to procure fish on a daily basis. However, the lack of refrigeration and storage facilities imposed demands on financial assets as vendors incurred additional costs of procuring ice with transportation costs and complex logistics.

While previous hurricanes have had major impacts on fisheries in Dominica, the extent of flooding during Hurricane Maria also had substantial impacts on housing and other land-based assets. Physical impacts on assets were described as having a 'levelling effect', impacting both rich and poor. Some institutional respondents commented that more affluent communities had greater levels of financial assets and insurance that may facilitate faster recovery, while poorer communities suffered from weaker infrastructure and fewer services to support recovery. On the other hand, some respondents observed that assets alone made little difference since affluent citizens were less able to cope mentally with the shock compared to the less affluent who were accustomed to "make-do" daily with fewer assets.

Efforts to restore and rebuild assets highlight the importance of Dominica's relationships with international organizations and agencies. In the immediate aftermath of

Table 1. Summary of key findings across five domains of adaptive capacity (following Cinner et al. 2018).

Adaptive capacity domain	Summary of findings
Assets (the assets people draw on in times of need, including individually-owned assets and public goods)	• Impacts on fishing assets were variable – return to fishing was quick where assets were not severely impacted • Fishers and vendors impacted by damage to shared infrastructure and services • Existing assets aided household recovery, but both poor and wealthy impacted • Disaster response included cash transfers and replacement assets, but some concerns about equitable distribution and understanding of community needs • Livelihoods projects and disaster preparedness seek to bolster household and community assets • Plans to adopt national level parametric fisheries insurance • Replacement of infrastructure with intention to 'build back better', but some rebuilding of assets was maladaptive
Flexibility (the ability to change strategies both within and between livelihood activities)	• Flexibility in inshore and offshore fisheries restricted by limited recovery of market and reliance on external assistance to restore this • Fishers adapt by selling their catch directly – vendors potentially lose out, with poverty/gender implications • Impacts on inshore environment restrict flexibility of inshore, often older, fishers • Flexibility of livelihoods to diversify beyond fisheries was mixed • Both poor and wealthy households may have limited flexibility • Disaster response provides some short-term employment • Off-island social connections facilitated flexibility • Livelihoods initiatives seek to promote diversification and sustainability
Social organization (the ability to act collectively and across social scales)	• Communities with strong self-organization perceived as more resilient post-Maria • Transboundary bridging ties facilitated flexibility and asset sharing • Community level disaster management committees established but not fully used • Perception of links to government leading to political patronage, but vertical links also important for learning about community needs • CREAD seeks to emphasize 'collective consciousness' • Cooperation among agencies for disaster response, but unclear coordination of oversight in relation to long term impacts
Learning (the capacity to recognize and respond to change)	• Limited access to critical information and early warning – prediction is difficult • Data and information management is challenging, including limited socio-demographic data to inform disaster response and recovery • Some lessons have been learned from previous shocks, others have not ('building back better', prioritizing waste management solutions) • Coordinated governance response needed to institutionally absorb learning • Despite learning, responses limited by island characteristics and exposure to multiple hazards
Agency (power and freedom to mobilize resources and choose whether and how to adapt)	• Activism and advocacy to meet needs not perceived as viable by fisherfolk • Local and national fishing cooperatives have declined in activity and influence • Enhancing capacity of local organizations is a key strategy in resilience-building • Using local and traditional knowledge to enhance agency has not been pursued • Agency used to resist particular strategies may oppose wider adaptation efforts

Hurricane Maria, replacement and repair of assets and infrastructure was supported by international aid agencies. Following a post-disaster needs assessment, a US$7m World Bank program to assist people to return to agriculture and fisheries enabled cash transfers of XCD$3-10k (approximately US$1100-3700) to individual fishers and farmers to compensate for loss of income and enable recovery. Agencies such as FAO provided support for farmers and fisherfolk while agencies such as the Red Cross are still supporting communities to prepare assets for future storms by stocking containers with relief supplies such as food, water purifiers and VHF radios.

Major initiatives are underway to protect and restore assets. The Government's Fisheries Division highlighted plans in progress for the implementation of a fisheries-specific insurance scheme through CCRIF which is expected to enhance response and recovery to future shocks and avoid the depletion of state resources in responding to successive shocks. The World Bank DVRP project involves investment in major infrastructure such as roads and bridges, and at a national level CREAD seeks to demonstrate the potential for "building back better" through flagship capital-intensive infrastructure projects. More broadly, ongoing projects preceding Hurricane Maria seek to build assets through community projects to promote enhanced agricultural production, the development of secondary systems including water storage and renewable energy development, and the maintenance of community buildings to promote both sustainable livelihoods and climate resilience. UNDP also highlighted the role of the UN Sustainable Development Goals as a guide for future resilience, emphasizing that efforts to build assets must be broader than buildings and infrastructure.

Challenges relating to the recovery and building of assets to support adaptive capacity include issues of distribution. With respect to fisheries, data on past activity of individuals that could provide the basis of decisions about the allocation of relief are often unavailable. A few fishing community members questioned the way in which some types of relief were distributed in specific locations, alleging that decisions were politically biased to reward supporters, although they offered no proof of this. There were also challenges within the relief response in either understanding or accurately communicating local needs, with some replacement assets provided by donor organizations (e.g., some insulated containers and ice machines) being inappropriate for use in fisheries. Administrative errors in procurement specifications were thought to be part of the problem. Existing inequality in the distribution of assets influenced individuals' ability to adapt and respond. While cash transfers were not necessarily intended to replace assets, those who had access to existing capital or sources of credit were able to combine this with assistance funds to purchase new equipment and return to fishing more rapidly. Some fishers and vendors were unable to return to the fishery after their losses. More broadly, more than 200 people without land assets or social capital remained in shelters two years after the hurricane in Dominica.

Rebuilding of assets to support future resilience in Dominica is complicated by vulnerability to a wide range of natural hazards. For instance, some households have considered replacing galvanized roofs with concrete, yet respondents noted that this may increase vulnerability to seismic shocks. In other cases, building of assets has been seen by both fisherfolk and some institutions as maladaptive, for example undermining resilience by focusing on hard defenses like sea walls rather than soft engineering, or

reinforcing vulnerability through provision of services such as electricity and water to communities rebuilding in vulnerable areas (e.g., floodplains of rivers).

Flexibility

Because fishers in Dominica typically target both offshore and inshore fisheries, many fishers have a degree of flexibility within fishing livelihoods through their ability to modify their fishing practices. Some respondents suggested that where assets remained intact, fishers were able to adapt reasonably well because they are more highly dependent on offshore pelagic species than on the inshore fishery, which was more heavily impacted by siltation and debris from the hurricane. In contrast, where offshore FADs were lost at sea, some fishers reverted to fishing inshore, including reported activity in the SSMR where fishing is prohibited. Limited recovery of fishing activity has reduced the volume of fish entering the main market facility in Roseau. The recovery of the fishery remains restricted by limited physical market functionality due to the damage to shared infrastructure and services, and exacerbated by reduced demand for fresh seafood from businesses and hotels. Although not engineers, a prevailing view of fisherfolk was that the Roseau market could be restored to nearly full functionality if there was government flexibility not to rely on external assistance for its repair. Because of the lack of storage and refrigeration, some fishers and vendors began selling fish on the roadside instead of at the market facility, shifting the dynamics of competition and potentially reducing opportunities for the (mainly female) fish vendors operating at the market facility.

Flexibility of fishers was considered to be reduced by both the impacts of and response to Hurricane Maria. The disposal of hurricane-related debris in coastal areas, and outflow of sediment from subsequent river dredging, were both reported to have had negative impacts on inshore ecosystems and fisheries. Fine sediments become resuspended with each subsequent high energy event, thereby prolonging the perturbation and delaying habitat recovery. These impacts may have disproportionality impacted fishers who rely more heavily on inshore fisheries, often older men with fewer financial assets or those who fish mainly for subsistence. Respondents highlighted the importance of waste disposal strategies and long-term planning to avoid such negative impacts in future.

Livelihood flexibility beyond fisheries was mixed. Respondents reported that some fishers and vendors left the industry altogether, with some remaining unemployed. Immediately after the hurricane, fishers with boats were able to benefit from the need for transportation of people and goods by sea because of the impacts to road infrastructure. Fishers also took advantage of jobs with international organizations (e.g., construction, roofing) but in the longer-term they resumed fishing or found it difficult to diversify. Fishers who had lost assets reported diversifying into both legal and illegal trading with nearby islands, and these links have persisted since. Respondents also reported that individuals with friends and family overseas had left Dominica after Hurricane Maria, with some having yet to return.

Ongoing programs in Dominica have sought to build capacity to support environmentally sustainable livelihoods, including use of biodegradable fish pots, sustainable

land management, tree planting, and waste management. Aspects of diversification have been promoted through re-sale of fish waste and promotion of industries such as cassava and arrowroot processing that are important in areas where hotels closed down after the hurricane.

Flexibility in responses to Hurricane Maria was seen to be socially differentiated. Poorer communities were considered by some to be less flexible, particularly because of having few options about where to move or rebuild after hurricane damage, or because they lacked a safety net. Conversely, wealthier individuals who had retired from overseas and returned to Dominica were reported to have been severely impacted because they had invested their assets in property and had few remaining options. The potential for relocation of entire communities away from hazardous areas was discussed by several respondents, highlighting the pressing challenge of identifying how such relocation might impact livelihoods and human wellbeing.

Social organization

Social relationships within communities played a key role in the immediate response to Hurricane Maria, for example bonding social capital was utilized as fishers cooperated to haul boats onto land in response to warnings, or collectively replaced FADs that were lost after the storm. However, fisheries cooperatives that were active in the past were noted to have declined in capacity and were no longer playing a strong role in supporting collective action. Respondents from institutions involved in disaster response described communities that seemed more resilient as being "a nation within a nation", with strong local organization and bridging social capital links to communities on other nearby islands supporting recovery. These connections provided important transboundary relationships that facilitated diversification and access to physical goods and assets in the aftermath of the hurricane.

Community level organization was highlighted as critical to support disaster response and recovery. Respondents noted the importance of education and awareness-raising to support community-level plans, especially in remote villages that can be easily cut off. In fishing communities, respondents discussed the importance of prior planning to identify areas to store fishing boats, though in some cases such organization was constrained by geography resulting in few opportunities for relocation, and lack of assets including trailers to move boats. Strong social organization was also recognized as an important factor underpinning diversification and flexibility, with past experiences of livelihood projects highlighting the importance of local organizations to monitor, evaluate, and coordinate for sustained success. Some institutional respondents perceived that the responses to Tropical Storm Erika and Hurricane Maria did not make effective use of the disaster management committees that are established in most communities, leading to some resentment among community members. Associated with this was a perception of political patronage in the response to Hurricane Maria. Linking social capital via connections to government is unevenly distributed, but it was perceived by some to be influential in determining assistance, with assets to support fisheries recovery not necessarily reaching those most in need. However, linking social capital was also

emphasized as a source of learning among responding institutions who liaised with communities to understand local impacts and needs.

In large-scale climate resilience initiatives, the social organization of communities has received mixed levels of attention. In efforts to enhance future resilience, the Climate Resilience Executing Agency of Dominica (CREAD) emphasizes social and community development as one of its three work areas. One of CREAD's key themes is collective consciousness, aiming to build responsibility and capacity for individual and collective resilience, and to create space for communities to share their experiences. In contrast, the World Bank Disaster Vulnerability Reduction Project was reportedly not directly funding any activity to build community capacity. There are intersections with poverty and gender given the predominance of women in fisheries postharvest livelihoods, with an undocumented but likely large proportion of them being from female-headed households either in or on the edge of poverty.

At a national level, disaster risk management is based on a community network response in which despite no formal inter-sectoral coordination mechanism, cooperation among national and international agencies is critical to effective action. Challenges highlighted included a lack of oversight or accountability for the downstream impacts of responses. For example, respondents perceived that the dredging of rivers post-hurricane and challenges of solid waste management that led to material being deposited in coastal areas had impacts on coastal ecology and fisheries that were not anticipated. Several institutions expressed support for a coordinated national disaster management plan and a mechanism for the inclusion of different agencies.

Learning

Access to critical information remains a challenge in Dominica. Efforts to establish a national fisheries early warning and emergency response system are ongoing. Dominica's distinctive topography creates hydro-meteorological conditions that are not well-predicted by wider forecasting. Challenges of forecasting rainfall intensity and duration made it difficult to warn of the flooding that was a major cause of damage during Hurricane Maria. The World Bank Disaster Vulnerability Reduction Project has a focus on data and information management that seeks to strategically address some of these challenges through enhanced environmental monitoring.

Data and information management capacity was perceived as a challenge nationally by institutional representatives. Data collection and analysis for evidence-based decision-making is limited by human resource constraints. Data sharing across institutions was perceived as having scope for improvement through greater use of open data. Collaboration with international researchers and agencies was perceived as helpful to understand exposure to the wide range of natural hazards faced. Experiences of identifying needs post-hurricane highlighted the importance of understanding socio-demographics, livelihood activities and gender difference, which had not previously been a priority for data collection in sectors such as fisheries.

Dominica has been historically impacted by extreme events, and respondents outlined examples where lessons both had and had not been learnt from previous disasters. For example, some suggested that building standards had improved after Hurricane David

in 1979, but others emphasized that though building codes are in place, they were neither legally-binding nor regularly voluntarily complied with. Since Hurricane Maria it was noted that rebuilding materials provided were not necessarily accompanied by a requirement to 'build back better'. Some respondents felt that although lessons had been learnt from Tropical Storm Erika, the impacts of Hurricane Maria presented new challenges because of the greater extent of flooding from rainfall-swollen rivers that caused extensive damage in coastal communities, combined with storm surge from the sea in some locations. Others suggested that in some cases lessons from Tropical Storm Erika were missed, including recommendations about solid waste management, which proved to be a major challenge post-Maria. This challenge relates to a lack of assets in terms of funds or equipment to process or repurpose debris, and the availability of appropriate land to expand waste disposal. Several respondents perceived that improved waste management (including reduced plastics pollution, greater composting, and development of energy-from-waste technology) should be prioritized to improve resilience and avoid the environmental impacts of poor waste disposal undermining long-term sustainability. These issues relate to the challenge of governance in disaster response, highlighting the need for coordination in order to take an overview of the long-term impacts of land use planning and disaster responses, and knock on effects in social-ecological systems. Respondents also noted that despite any learning, new responses are limited by the characteristics of the island landscape and climate, whereby responses to reduce one risk may increase exposure to another.

Agency

The ability and willingness to mobilize and act in response to change is important for activating other dimensions of adaptive capacity. Among individual fishers, activism and advocacy were not widely perceived as viable options. Those who had not been able to go fishing since Maria and remained unemployed stated that local lobbying, activism and advocacy were not going to address the situation, and expressed little inclination to organize or advocate for their needs to either the Government's Fisheries Division or other agencies. There was alleged fear of individual victimization from speaking-out. Community-based fishing cooperative societies, which in the past represented boat owners and fishers, and assisted in facilitating collective action, have declined in activity and no longer seem to be fulfilling this role. The national, umbrella, fisherfolk cooperative body was also said to have weakened mainly due to inconsistent leadership. Fishers and vendors emphasized the role of the Government in supporting recovery and development of assets in the fishery, and other respondents suggested that resource users fear the political implications of "being too activist". Though national policy seeks to be enabling of adaptation and recovery from Hurricane Maria, political realities are perceived as key constraints in determining how assistance is distributed. Fishers also expressed reservations about their ability to plan for future extreme weather events, suggesting that they would work hard, manage their finances, and "just hope for the best".

A key element of resilience building strategies in Dominica is the aim to strengthen local organizations and their capacity, empowering people so they are able to respond

and adapt to future shocks. Agencies such as the Red Cross are engaged in training community members to prepare disaster plans, identify evacuation procedures, assess damage, and rebuild in more resilient ways. This is especially important where communities are cut off and require local leadership and capacity to respond. Opportunities for communities to partner with government and other agencies can help develop local agency, yet institutional respondents also recognized challenges as engagement of communities relies on willingness and goodwill. Participatory processes may be facilitated by strong social organization; respondents noted that communities with previous experience and strong local leadership showed a more proactive response than others. At the same time, there are limits to what communities can achieve, and recognizing where external action or support is needed is critical.

Respondents from institutions noted that after Hurricane Maria there were attempts to bring government bodies and other agencies together to review and push forward draft legislation and new activities to promote resilience. Developing alternative visions for the future is an important part of building agency, and CREAD is intended to play an important role in thought leadership about how to become more resilient, while acknowledging that natural hazards have played a prominent role in Dominica's history and resilience and adaptive capacity are therefore not new to local people.

Though learning from local and traditional knowledge can be an important strategy in responding and adapting to change (Pahl-Wostl 2009), some respondents noted there has been limited interest in actively learning from traditional Kalinago practices. These include traditional approaches to resilience – for example the use of dowels rather than nails in construction. These seldom penetrate society outside the indigenous territory. Traditional approaches are perceived as old-fashioned, although some old wooden houses fared better than more modern concrete houses in response to extreme weather. Some respondents perceived that since the Kalinago people are quick to adopt new technology, narratives of modernization are undermining Kalinago resilience based on traditional practices. For example, they see this through the loss of traditional knowledge and skills required to identify and fell the most suitable trees for construction of wooden dugout canoes.

Strong agency can both support and undermine resilience, because agency can be used to resist or oppose wider adaptation efforts. Two examples of this challenge were highlighted. First, respondents noted people's resistance to relocating after a disaster because their preferences about where to live may be driven by factors other than vulnerability to hazards. Second, fishers expressed distrust of insurance schemes based partly on their prior experience of insurance policies not paying out when they were expected to, and partly on the basis that they perceived insurance to be designed for large-scale fishing operations rather than small boats. Although weather insurance schemes for fisheries recently launched in the Caribbean operate at a national scale, with payments made to national governments when weather indices are triggered, their effectiveness may be hampered if fishers choose not to engage with them. Related to this, some fishers reported a reluctance to engage in formal data collection schemes, information-sharing, or contributing to social security payments. Fishers attributed this reluctance to a perception that "nobody cares for fishermen in Dominica", yet a failure to formally record fishing activity may impede fishers' ability to document their livelihood and

potentially therefore restrict their access to assistance in the event of extreme weather, as well as to secure access to other assists such as loans that may support recovery.

Discussion

This study has identified important challenges faced by coastal communities in responding to extreme weather events. As primarily a scoping field study, this research was not intended to provide a theoretically comprehensive analysis of adaptive capacity in coastal communities of Dominica. It points, however, to key areas for practical consideration in targeting efforts to enhance resilience and identifies critical areas for applied research into operationalizing the concept of adaptive capacity.

The abilities of fisherfolk to access and deploy different sources of adaptive capacity in response to Hurricane Maria were differentiated by individual attributes such as gender and wealth, as well as by community characteristics and geography. A qualitative perspective on these experiences draws attention to contextual social, political and environmental factors that tend not to be effectively captured in quantitative indicators of adaptive capacity (Lavoie et al. 2018). The historical, social and cultural factors that shape vulnerability to disasters means that solutions are complex (Barclay et al. 2019). Since marginalized groups are expected to be most severely impacted by climate change (DFID 2006), strategies to build adaptive capacity must consider these socially-differentiated needs and their intersections with poverty and gender to ensure that shocks and responses to them avoid exacerbating existing inequalities.

The findings illustrate how adaptive capacity domains are closely interrelated and often synergistic. For example, livelihood flexibility after Hurricane Maria was linked to assets and social organization. Cinner et al. (2018) highlight areas for future research concerning the dynamics of these interactions, including for example the extent to which capacity in some domains underpins that in others. In Dominica, our findings suggest that building a strong civil society should be a priority to enhance both social organization and agency. Awareness of this is implied in the support for local governance and a focus on community-based disaster risk management, but more systematic analysis could strategically aid their implementation. Attempts to enhance adaptive capacity and support recovery from shocks can be influenced by power asymmetries and political dynamics that constrain adaptive capacity in order to maintain power. These dynamics can be exacerbated where a weak civil society perpetuates the dependence of coastal communities upon government and external assistance. Efforts to strengthen adaptive capacity by enabling self-organization and agency within communities would be compatible with the community-based modular disaster risk management initiatives that are favored in the Caribbean and pursued in Dominica (CoD 2018), and consistent with wider calls to engage community capacity in recovery planning and governance (Wilkinson 2018). Incorporating local and traditional knowledge can also support strategies to promote agency within communities (Cinner et al. 2018).

Though the framework of Cinner et al. (2018) focuses on individuals, households and communities as the key area in which adaptation takes place, our findings also illustrate how the effectiveness of institutions engaged in responding to change is critical in enabling or undermining local adaptive action (Jones et al. 2010a). Our findings highlight

an important role of institutions in prior planning and collaboration to develop a common vision that can catalyze adaptive collective action. Prior planning to support 'building back better' is important to avoid the mismatch of needs and responses identified by respondents, and to enable resilient re-building to meet the need for a rapid response (Wilkinson 2018). This requires improved information-sharing, a common vision and networking for collective purpose. The role of CREAD in enhancing coordination and cooperation across agencies has the potential to be transformative in this regard in Dominica. Such coordination can also help to avoid maladaptation (Barnett and O'Neill 2010). Immediate responses to a disaster can be maladaptive, undermining the adaptive capacity of some stakeholder groups now or in the future. The examples of poor waste management and ill-advised river dredging that contribute to nearshore environmental degradation in Dominica highlight the need to consider social and ecological dynamics to support responses that enable long-term flexibility. Though important ecosystems both support livelihoods and provide some protection against hazards, attention to restoring 'green infrastructure' often receives less attention than 'grey infrastructure' such as roads and buildings (Wilkinson 2018). This imbalance can be worsened if major international recovery and rehabilitation financing is associated primarily with highly visible physical engineering or goods procurement projects as seen in Dominica. A predominantly infrastructural perspective on adaptation runs the risk of overlooking social and cultural dimensions of resilience including the traditional knowledge such as that of the Kalinago, or the important roles played by women.

The findings highlight the importance of understanding people's perspectives and concerns to ensure that wider adaptation efforts are compatible with these. For example, new parametric fisheries insurance initiatives recently launched in the Caribbean could help to protect and recover assets and enhance flexibility (CCRIF SPC 2019; Sainsbury et al. 2019). However, the negative perceptions of record-keeping and insurance first need to be overcome in order to ensure that the potential benefits reach all vulnerable groups. External interventions that do not fit with local perspectives may lead to resistance, which can be an important component of agency and social resilience (Brown 2015). Importantly, while opportunities for enhancing adaptive capacity can be identified, limitations must also be recognized in the context of the complex hazard landscapes facing many SIDS. For instance, adaptive responses to one hazard may increase vulnerability to another, and in extreme cases of devastation migration may be an essential adaptive option with the consequence of losing human resources for recovery, including outmigration of skilled workers (Wilkinson 2018).

Conclusions

The adaptive capacity concept is a useful heuristic, particularly to identify the intangible resources that people draw upon in responding to change. Our findings from field scoping highlight that adaptive capacity can be highly nuanced and specific to a particular situation or period. Vulnerability issues may be broadly similar across a small island, but different socio-demographic or stakeholder groups can be impacted in different ways, and may draw upon each adaptive capacity domain for problem-solving differently, making it difficult to generalize about how to build resilience without detailed

knowledge of the situation and people. Adaptive responses to shocks can also be enabled or constrained by relationships between different stakeholders both within the fishery (e.g., fishers and vendors) and across wider society (e.g., through transboundary connections). For example, though some had the appropriate assets to return to fishing, they remained partly constrained by the limited recovery of vendors' activities and related markets. While the framework of Cinner et al. (2018) focuses primarily on community-level adaptive capacity, the respondents considered that governing institutions involved in disaster response and climate resilience have a key role to plan in enabling or constraining local-level adaptive capacity. A qualitative approach can shed light on these complexities of adaptive capacity that may not be captured by aggregate indices and can inform an understanding of adaptive capacity across the fisheries sector and coastal communities. This scoping study has assisted in framing areas for attention and could be usefully expanded through further research. Regional capacity building to develop interdisciplinary and social science expertise can help to strategically inform efforts to build adaptive capacity based on a more thorough understanding of the actors.

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