



KNOWLEDGE AND ACTION GAPS AT THE INTERSECTION OF CLIMATE HAZARDS, PUBLIC HEALTH, AND ENERGY RESILIENCE IN PUERTO RICO

A Report to the National Oceanic and Atmospheric Administration for the Competition for collaborative planning activities in the Southeast and the U.S. Caribbean (CPO, RISA Program FY2021: NOAA-OAR-CPO-2021-2006677)

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TABLE OF CONTENTS

- 05 Project Overview
- 08 Cascades in Climate Hazards, Public Health,
and Energy Resilience
- 10 Project Activities
- 14 Co-Developing Stakeholder Engagement
- 16 Organizations Working at the Intersection
of Climate Hazards, Public Health, and
Energy Resilience
- 19 Interactions Between Climate, Public Health,
and Energy
- 21 Knowledge Gaps
- 23 Actions Gaps
- 27 Conclusions and Key Messages
- 28 References
- 29 Appendix 1: Workshop Participants and Agenda
- 31 Appendix 2: Workshop Program
- 35 Appendix 3: A Blended Stakeholder
Engagement Approach: Tradeoffs in Combining
Remote and In-person Activities

PROJECT OVERVIEW

In Puerto Rico, a history of recurrent extreme climate events coupled with marginalization, political crises, and lack of governmental support catalyzed a groundswell of community-based organizations (CBOs) with increasing influence on the island's sustainable development (1). Many CBOs focus on climate hazards, energy access and security, and human health but often operate independently of each other. Planning for co-occurring, consecutive, or cascading extreme events marks an important new frontier for climate-smart development, and synergy among these groups is needed to address emergent risks (2).

The back-to-back hurricanes of Maria and Irma that struck Puerto Rico within two weeks of each other in 2017 illustrated many feedbacks and relationships among these three domains. The hurricanes brought immediate and tragic damage to property and lives. But the effects of the storms were long-lived. They caused the longest power outage in U.S. history (3), for example, up to 10 months in some places. The lack of energy likely led to public health impacts, including heat-related illnesses and elevated morbidity for people with chronic diseases who could not refrigerate their medications or use essential medical equipment (e.g., Ortiz et al., 2020). Furthermore, the disruption of everyday life prevented some individuals from earning an income and thus their ability to pay for basic services like electricity and health care.

Complex hazards like Maria and Irma lead to both predictable and unanticipated consequences across space and time (5). However, despite their large geographic and temporal

impacts, there has been little integrative research on them, particularly in the context of future climate adaptation (5, 6). In this context, this project engaged local experts and stakeholders in public health, energy access and security (hereafter energy resilience), and climate hazards—particularly those part of CBOs—to co-create a knowledge and action gaps learning agenda.

The project was a collaboration between the University of Arizona (UA) and the University of Puerto Rico (UPR). It drew on transdisciplinary and co-production approaches to engage a community of scientists and professionals working in Puerto Rico. The project consisted of four steps (Figure 1).

In the following white paper, we report the organizations working in the fields of climate hazards, public health, and energy resilience in Puerto Rico. We discuss the knowledge gaps as they pertain to the intersection of these three domains. We go beyond problematizing the nexus of climate,

public health, and energy resilience in Puerto Rico. Rather, the stakeholder engagement was designed to identify actions to make Puerto Rico more resilient to complex hazards as well as to identify the clusters of organizations willing and able to embark on these actions. Both the knowledge and action gaps are therefore meant to be instructive as opportunities for future research.

In addition, this project was transdisciplinary by design. We therefore offer a complementary analysis of the tradeoffs in stakeholder engagement research in a post-pandemic world where remote engagement techniques are becoming more common while, at the same time, dislodging to some extent “in person” modes of collaborative research.

In totality, this white paper should be read as a chart for both research and implementation in Puerto Rico that address important issues at the intersection of climate adaptation, public health, and energy resilience.

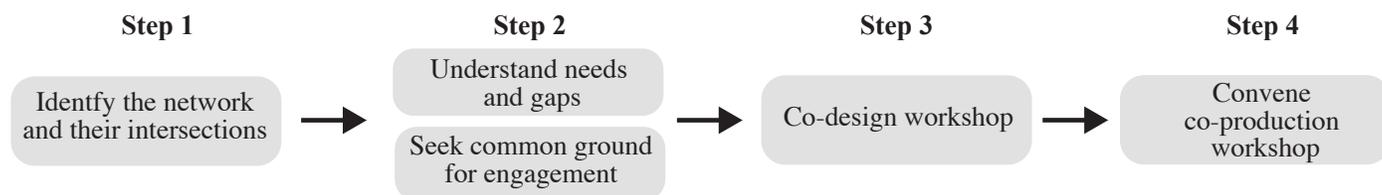


Figure 1. The project’s implementation framework. The steps are progressive.



CASCADES IN CLIMATE HAZARDS, PUBLIC HEALTH, AND ENERGY RESILIENCE

An important frontier in climate adaptation research is to account for cascading impacts that result from compound extreme events with co-occurring or sequenced social and environmental shocks. Cascades amplify the impacts of an event, such as a hurricane or extreme heatwave, or deepen the underlying social or environmental conditions that reinforce vulnerability to the event. Some of the most damaging events occur from compound events. The floods in Pakistan in late August 2022 are the most recent illustration. There, a heatwave first accelerated the melting of glaciers and caused high river flows. Then, torrential regional monsoon rains caused massive flooding. In the immediate aftermath, more than 33 million people had been affected, and this doesn't account for the cascading impacts related to diseases and food insecurity that will lag in time (7).

Compounds can occur in many combinations. They can be a sequence of storms that strike the same region, as was the case in 2017 when Hurricanes Irma and Maria struck Puerto Rico within two weeks of each other. They can be a sequence of events that affect different regions but deplete the collective resources to respond, which occurred when Hurricanes Harvey and Irma struck Texas and Florida, respectively, weeks prior to Hurricane Maria devastating Puerto Rico (2). They can include war in regions with globally important commodities such as fertilizers, in the case of the War in Ukraine that leads to massive food insecurity in Africa.

Cascades in climate, public health, and energy resilience are likewise numerous. Examples include the damage or destruction of energy infrastructure by cyclones that then lead to prolonged power outages. The cyclones can be followed by extreme heat (8), which increases the risk of heat-related illnesses and medical complications from pre-existing conditions (9, 10). Moreover, elevated heat can also lead to blackouts, which affects refrigerated storage for food or medical supplies, communication infrastructure,

and healthcare capacity (11). Furthermore, severe storms that damage water infrastructure can increase the risk of transmitting and contracting vector-borne and water-contaminant-related diseases (12, 13).

Cascades occur in a context that either amplifies or suppresses the impacts. Physical and social vulnerabilities often follow historic patterns of inequality across fault lines of class, gender, and ethnicity, and these characteristics are often predictive of impacts. Other important indicators of vulnerability include age, pre-existing health conditions, socioeconomic status, and geographic residence (12, 14–16). Several studies have highlighted how individual and regional differences such as isolation, disabilities, advanced age, and lack of health insurance coverage contribute to climate vulnerability (15). Given this, it is no surprise that Hurricane Maria affected disproportionately the more vulnerable groups in Puerto Rico (17).

The literature on cascades details links between climate, public health, and energy in the Caribbean, mainly as they unfold in the wake of cyclones. While climate adaptation that considers compounds and cascades treats climate risk holistically, this viewpoint is lacking in Puerto Rico. Such a view needs to account for interdependencies of social and environmental systems (6, 18) in ways that better specify the scope of connections in specific sectors (19, 20), better define 'high impact low probability' events (21), and better address the cumulative impacts of recurring shocks (22). In Puerto Rico, a more local and broader understanding of cascading impacts on communities and the environment is needed. Indeed those studies focused on Puerto Rico are often national in scale, largely emphasizing the urban centers (23), and hurricane-centric. Moreover, knowledge of how Puerto Rican organizations are addressing issues related to climate, public health, and energy will help translate a technical knowledge of cascades into practical actions (24). This report addresses these gaps.



PROJECT ACTIVITIES

The project activities followed a sequencing logic that developed foundational knowledge, identified actors in Puerto Rico working on climate hazards, public health, and energy resilience, engaged with a small group of committed individuals to plan a participatory workshop, and then convened the workshop (Figure 1). In this section, we describe the activities listed in Table 2. The interviews and workshop activities obtained Internal Review Board approval from the University of Puerto Rico - Medical Science Campus on 01/24/2022 (Protocol Number: B1540121).

Inventory of organizations and institutions. We drew on the four sources of information to inventory the organizations in Puerto Rico working on climate, public health, and energy issues: Puerto Rico Department of State; Google search; social media platforms of Facebook, Twitter, and Instagram for organizations; and on the team's local network and their referrals. We searched the Department of State database using keywords of "climate", "public health", "energy", "health", "green", "resilience", "renewable", "environment", and "sustainable." We searched in both English and Spanish languages; we further screened the web and social media results using the same keywords.

We ultimately developed a database of 85 organizations that met the following criteria.

- The organization was actively working in Puerto Rico.
- The organization was based in Puerto Rico.
- The organization works on the topics of climate, public health, or energy.
- The organization provided contact information (e.g., phone number or email).

Needs Assessments of Organizations and Institutions. We attempted to contact all 85 organizations to set up interviews, either by calling telephone numbers, if available, and/or sending emails. For organizations with phone numbers, we varied calling times across weekday mornings, weekday afternoons, and on the weekend. We attempted at least three separate calls to each organization. We also sent an invitation to participate in an interview to the email address provided on the organization's webpage.

Table 1. Project activities and their corresponding methods and goals. “Steps” correspond to Figure 1.

Steps	Activities	Methods	Goals
1,2	Literature Review	Desk research of academic literature	Understand knowledge base of cascades, with focus on climate, public health, and energy resilience in the Caribbean and Puerto Rico.
1	Inventory of organizations & institutions	Desk research of publicly available databases and web research	Identify range of actors in Puerto Rico working on issues related to climate hazards, public health, and energy; identify priority actors to interview.
1	Needs assessments of organizations & institutions	Conduct semi-structured virtual interviews of actors identified in the organizational inventory and from referrals during interviews.	Understand how some actors perceive the connections between and the main knowledge gaps pertaining to climate, public health, and energy; identify individuals to co-develop the participatory workshop.
3	Workshop co-design	1-day in-person meeting with planning committee; routine remote planning meetings	In-person meeting builds rapport and develops common goals for the workshop; remote meetings develop the workshop program.
4	Participatory workshop & follow-up	1-day participatory workshop; post-workshop participant survey	Develop and refine the learning agenda.

We interviewed 19 organizations in a semi-structure format. Each interviewee represented an organization that worked on either climate hazards, public health, or energy resilience (Figure 2). Interviews lasted about 30 minutes, were conducted in the preferred language of the interviewee (English or Spanish) and performed by two team members. The interviews discussed the main challenges Puerto Rico faces related to climate change, public health, and energy. They also focused on understanding each organization’s main concerns and priorities as well as their knowledge gaps. We also sought referrals of organizations we should contact, and we invited each organization we interviewed to participate in the forthcoming workshop.

Workshop Planning Committee. The planning committee consisted of six collaborators and four project team members (Table 2). The six committee members were all interviewed, and they were selected based on their enthusiasm and willingness to participate. On April 6, 2022, four members of the committee and three individuals from the UA and UPR project team met in person at the Medical Sciences Campus at the University of Puerto Rico in San Juan. At this meeting, the planning committee discussed the goals of a participatory stakeholder workshop, the date and location

of the workshop, and its program. The planning committee also set in motion a process to refine the program and invite participants. Over the subsequent three months, the planning committee met virtually five times and met in person the day prior to the workshop.

Participatory Workshop and Post Workshop Engagement.

We hosted a workshop on June 23, 2022, from 8:00 AM to 4:00 PM at Nuestra Escuela in Caguas, Puerto Rico. The workshop, titled “Collaborative Planning for a Resilient Puerto Rico to Cascades in Climate, Energy, and Public Health,” brought together 33 participants representing 24 organizations. These organizations focused on one or more of the main workshop themes (Figure 2b). The organizations included representatives from CBOs, non-governmental organizations (NGOs), federal agencies, and academia (see Annex 1 for agenda and participant list). The participants represented diverse voices and whose work spanned the entire island.

The program was highly interactive, following a logic that moved from the establishment of common points of understanding of the three themes, to the identification of concrete actions to address areas of overlap. The program began with

presentations on the “big picture” of the climate and public health and climate and energy to frame the main discussion points of the workshop. Participants then characterized their work on climate, public health, and energy resilience, followed by discussions on how the three topics interacted and their knowledge gaps. The workshop concluded with a discussion of the actions needed to make the island more resilient to the cascading impacts of climate, public health, and energy resilience (see Annex 2 for a detailed outline of the program). We continued the final activity in a follow-up survey conducted online. The workshop activities and follow-up survey produced insights described in the following sections.

Reflections on a Blended In-person and Remote Stakeholder Engagement Approach. Stakeholder engagement was a main design principle of our project. The dominant models of engagement in climate adaptation and services is the “co-production” of science. At the same time, the COVID-19 pandemic has made remote methodologies more common, thus dislodging to some degree the co-production paradigm. In this context, our team deliberated throughout the project on how to maximize the benefits associated with remote activities, while minimizing the loss incurred by not engaging in in-person activities. In Annex 3, we reflect on the tradeoffs in replacing some in-person engagement with virtual engagement.

Table 2. Members of Workshop Planning Committee who are not part of the research team.

Name, Position	Organization	Description
Yasmin Detrés, Education & Outreach Coordinator	The Caribbean Coastal Ocean Observing System (CARICOOS)	CARICOOS is the regional association for the coastal and ocean observing system for Puerto Rico and the U.S. Virgin Islands. CARICOOS works with diverse stakeholders who require coastal seas and weather information for their decision-making.
Lillian Ramirez, Research Associate, Coastal Communities Development and Climate Extension	Sea Grant, the University of Puerto Rico	Sea Grant College Program is an educational program dedicated to the conservation and sustainable use of coastal and marine resources in Puerto Rico, the US Virgin Islands, and the Caribbean region.
Justo Méndez, General Coordinator	VAMOS	VAMOS engages in education, organization, and mobilization in the service of creating a sustainable, inclusive, supportive, democratic, fair, equitable, prosperous, healthy, and happy country.
Wanda Crespo, Adaptation Specialist	NOAA-Regionally Integrated Sciences and Assessment (RISA) program	RISA helps decision makers and researchers collaborate on adapting to climate change. Via regionally focused and interdisciplinary research and engagement teams, RISA expands the Nation's capacity to adapt and become resilient to extreme weather events and climate change.
Federico Cintrón Moscoso, Director	El Puente	El Puente is a human rights institution that promotes leadership for peace and justice through the engagement of members in the arts, education, scientific research, wellness and environment.
Marcel Castro-Sitiriche, Co-director	Center for Hemispheric Collaboration in Research and Education in Engineering and Applied Sciences (CoHemis)	CoHemis promotes and facilitates the development of human resources, technology, and programs that assist research and education in science and engineering for the benefit of the countries of the Western Hemisphere.



CO-DEVELOPING STAKEHOLDER ENGAGEMENT

Several project guidelines were *a priori* defined at the proposal stage. These included addressing common issues to climate, public health, and energy resilience and working *with* diverse stakeholders to identify knowledge gaps. Beyond that, the engagement activities defined the details of how the project was framed, who participated, and how participation manifested. In this section, we describe the key insights generated from the interviews and planning committee discussions that affected the stakeholder engagement.

Guidance from Interviews. The interviews informed engagement in four ways. First, the interviewees commonly highlighted a general and widespread lack of education and literacy about climate change in Puerto Rico. This confirmed a need to understand the knowledge gaps, and what actions could address them. We therefore designed the workshop to specifically identify knowledge and action gaps. Second, interviewees highlighted the need to create plans for recycling and reuse to deal with the waste generated in Puerto Rico. The interviewees discussed the topic of waste management in ways that showcased its connectivity to many other sectors. This emphasized a need to discuss interconnections and impacts and emphasized both a cascading impacts framework and sessions designed to draw out connections. Furthermore, the waste management discussion focused on solutions rather than knowledge gaps. This helped orient the workshop around finding action gaps. Third, interviewees described an urgency to comply with the Puerto Rico Climate Change Mitigation, Adaptation, and Resiliency Act, which states that Puerto Rico must establish climate change public policy and processes to mitigate, adapt, and increase resiliency by sector. This common point of reference further argued for a workshop that went beyond problematizing and sought to identify needed actions. Finally, the interviews identified the actors who would serve on a planning committee as well as those who should be invited to the workshop.

Guidance from the Planning Committee. The planning committee iterated on the workshop program during three months of preparation, in the process making four decisions. First, the committee decided that the goals of the workshop would: (1) identify knowledge and action gaps at the intersection

of climate, public health, and energy resilience; (2) strengthen relationships between organizations working on these issues; and (3) discuss opportunities for new collaborations. Importantly, the committee stressed the importance of developing action gaps that could move the island towards resilience. The committee recognized the project's commitment to its funder, NOAA, to provide knowledge gaps, but stressed that knowledge gaps are more known, while what people and groups could "do" is less emphasized.

Second, the committee stressed a program that generated outcomes that would be "useful" for the participants. The committee decided to craft a program to develop and strengthen relationships among the participants and foster social learning from participants. Furthermore, the workshop output would be reported in Spanish and would include an "address book" of the participants and their areas of interest.

Third, the committee emphasized a workshop format that increased participation. The location would be in Caguas, a city outside of San Juan, to facilitate attendance by participants living across the island. Caguas is on a main highway and is less affected by traffic congestion. The date of the event was selected to be before the peak of hurricane season in the Caribbean. Furthermore, the workshop would be in-person following local and government protocols amidst a resurgent wave of COVID infections. Several planning committee members had recently conducted in-person events that were well attended. Finally, the workshop would minimize presentations in favor of group discussions and activities.

Fourth, the committee discussed the need for a dynamic recruiting process to combat fatigue in stakeholder participation in virtual and in-person events, which was noted by several committee members. The recruiting process began with invitations sent to organizations identified in prior project activities. The low initial registration led the committee to first augment the invitations based on their professional networks and then by advertising on their organizational social media accounts. Preregistration was required so that the workshop would uphold its commitment to diverse representation that focused on the participation of community-based organizations.



ORGANIZATIONS WORKING AT THE INTERSECTION OF CLIMATE HAZARDS, PUBLIC HEALTH, AND ENERGY RESILIENCE

We characterized the network by organizations working on climate hazards, public health, and energy resilience. In total, we identified 151 unique organizations that had some relation to the workshop participants. The organizations were identified during a workshop activity, described in the following paragraph, and by subsequently reviewing the workshop participants' websites.

During the first workshop session, participants noted the projects they are currently working on as well as with whom they are collaborating on each of the projects. They then mapped their activities onto a Venn diagram, as shown in Figure 2. The different spaces represented degrees of intersection between climate hazards, public health, and energy resilience.

The workshop participants reported a total of 102 activities that were organized in six general categories of activities and described in Table 3. Participants reported more activities in the spaces of overlap between multiple sectors (61) than in the single sectors (41). Participants reported a plurality of their activities—a total of 31—as falling in the intersection between the three themes, located at the center of the diagram (some sticky notes have more than 1 activity). The pattern reveals an interesting reality about the participants' perspectives. Because many of them work with CBOs that address the impacts of hazards on communities, they may be pre-positioned to recognize the intersectionality of the issues and consequently design projects to account. This perspective may be complementary to that of activities by research and planning institutions, which are often more focused on singular issues. Additionally, the relatively higher number of activities in the intersecting spaces suggest a high prevalence of identified cascading impacts in Puerto Rico.

As noted, the highest number of activities were reported at the intersection of climate, public health, and energy resilience. While a diversity of activities was reported at this intersection, the most common mode of action reported involved capacity building such as hosting virtual and in-person trainings on agroecology and youth and climate justice as well as participatory planning for resilience and adaptation.

The predominance of capacity building projects may relate to the necessity of education and training as a precursor to other categories of action. For example, without building human capital it may be difficult to pursue actions related to planning, advocacy, or development/infrastructure. Capacity building may also be an attractive option for CBO activities because it requires comparatively less resources beyond labor and knowledge and works directly to empower communities for action and decision-making through education. The underlying reason for this emphasis on capacity-building is difficult to untangle, but it emerges as a recurrent theme of the project, surfacing again in our key findings regarding Action Gaps.

We further mapped the collaborators of workshop participants' stated activities in Figure 3. On this map the workshop participants are represented by the blue diamonds, while their reported collaborators are represented as red diamonds. The linking lines indicate identified collaborators between the two organizations. This map is not a complete representation

of the participant networks, but rather a snapshot of the specific, activity-based collaborations reported by participants in Session 1 of the workshop and on their websites.

The map shows three important characteristics. First, there are relatively few links between the organizations participating in the workshop. The relatively "isolated" character of the network diagram suggests that the project was successful in bringing together a new set of stakeholders. Second, each organization is working within their own networks and not in a siloed way. Local networks are perhaps a central characteristic of CBOs that are by nature largely focused on local level activities. Third, the action and knowledge gaps discussed at the workshop were likely enriched by the diversity of the participants and their seemingly limited collaboration on activities. A tightly linked group with a high number of connections might have created an environment where common knowledge and understanding was simply rehearsed in a new venue.

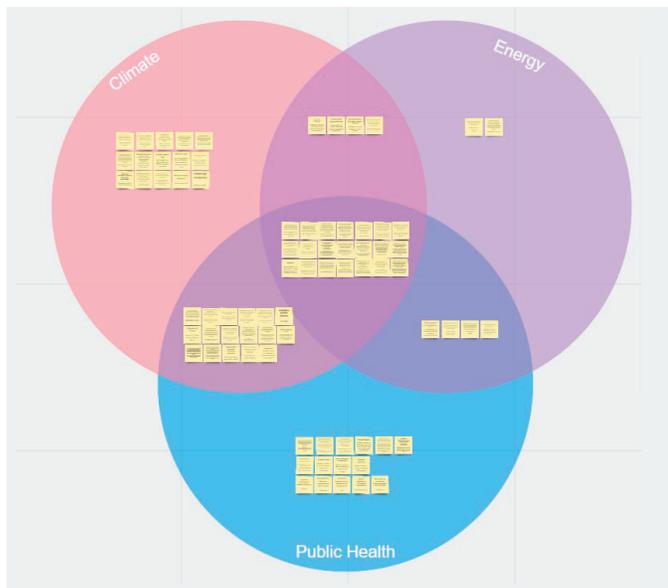
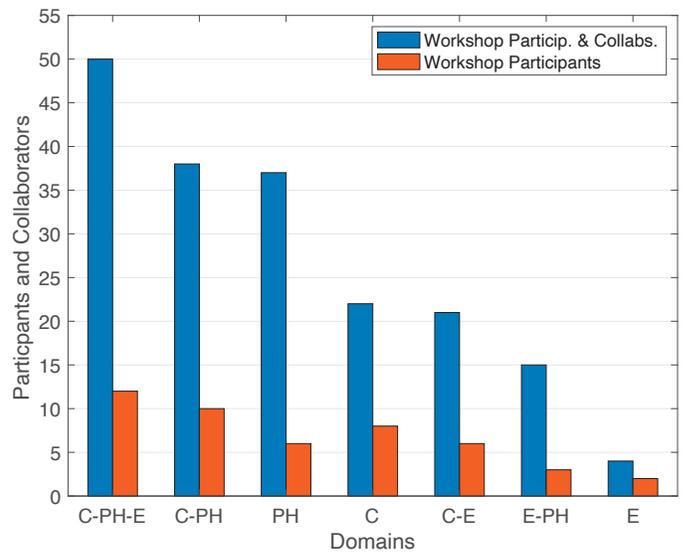


Figure 2: (Left). Participants mapped activities they are working on onto a Venn diagram to illustrate the different topics the activity addressed. The information on the yellow cards is discussed in the text and summarized in the bar chart on the right. For each activity, the participants noted who they are collaborating with.

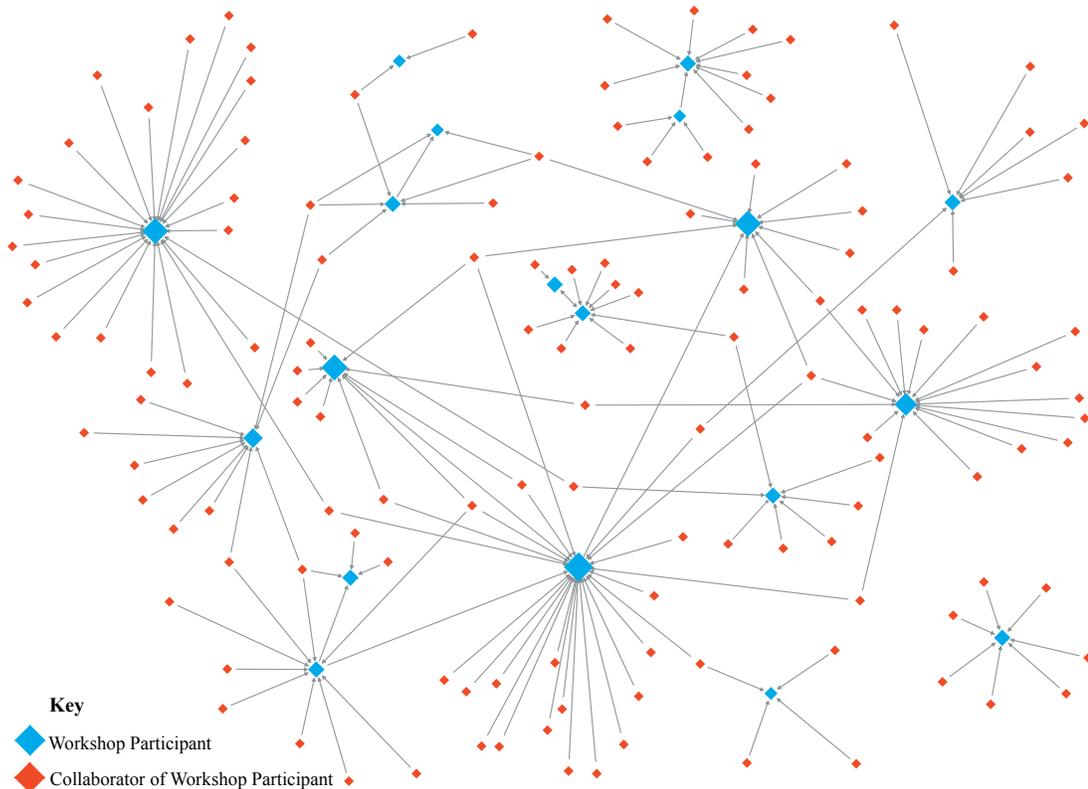


(Right) The workshop participants (blue) and the participants and their collaborators (red) are working on projects that address one or more of the domains: climate (C), public health (PH), and energy resilience (E).

Table 3. Workshop participants identified activities they are engaged in that group into six categories. We note our definitions of the categories that enabled the grouping and examples of each stated by the participants. The source attributed to each example below indicates the participant CBO that reported the activity. There may be a larger coalition of CBOs involved beyond the source organization.

Category	Definition	Examples of Participant Activity
Collaboration	Activities related to building inter-organizational cooperation where the main goal is network-building with other CBOs and institutions.	Meetings with Recinto Universitario de Mayaguez to promote collaboration on Sea Level Rise. Source: <i>Center for Rising Seas</i>
Research	Activities related to the generation of new knowledge.	Investigating the disproportionate impact of climate change on mental health in communities, methods for emotional recovery in impacted communities, and the impact of agroecology and permaculture on the mental health of project participants and farmers. Source: <i>CrearConSalud</i>
Capacity Building	Activities related to education and training of other stakeholder groups.	Technical assistance for the development of community resilience plans in 92 communities. Source: <i>Foundation for Puerto Rico</i>
Planning	Activities related to formalizing response and adaptation plans, including institution-building activities to define roles and responsibilities.	Creation of a Community Response Network and School Rescue Manual. Source: <i>VAMOS PR</i>
Collective Action / Advocacy	Activities related to leadership of or participation in collective action and advocacy.	Defense of the La Javea beach in Santa Isabel via participation and support of communities in their activities to confront the development of a hotel. Source: <i>Brigada Solidaria del Oeste</i>
Development / Infrastructure	Activities related to the construction and/or establishment of infrastructure that builds resilience, such as rooftop solar panels, community kitchens, and climate-smart agriculture.	Installations of solar systems in community centers. Source: <i>El Puente</i>

Figure 3. The network snapshot of the workshop participants.



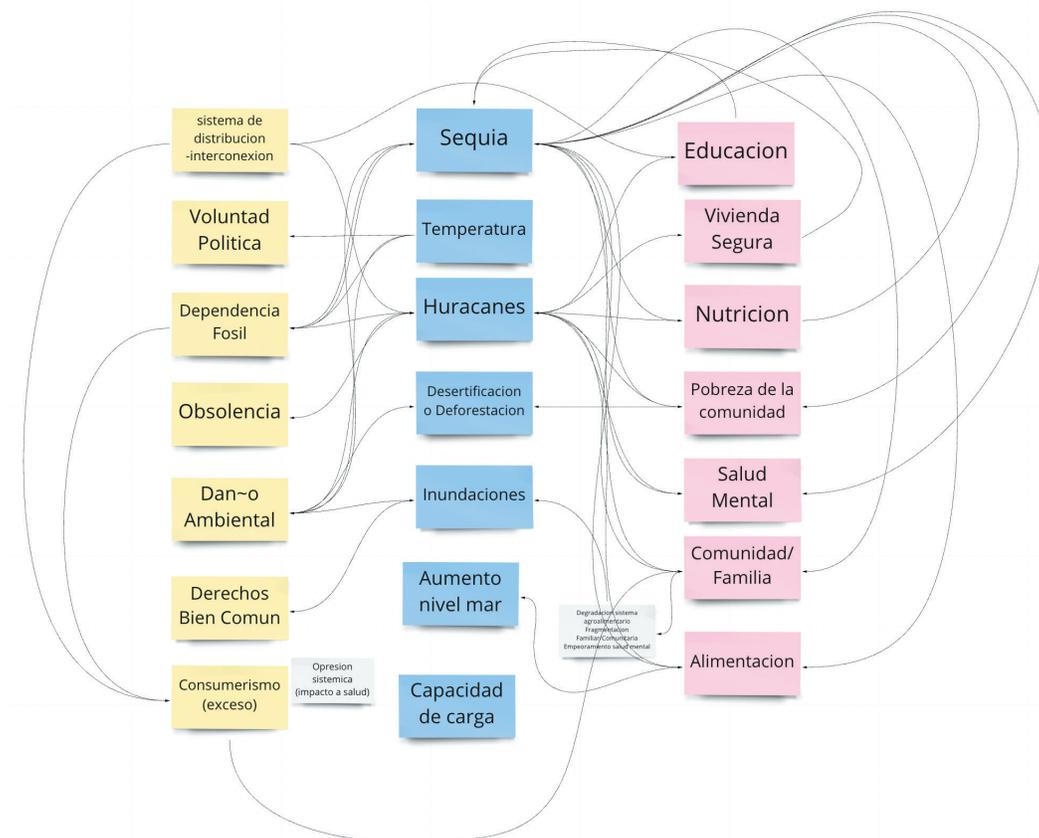
INTERACTIONS BETWEEN CLIMATE, PUBLIC HEALTH, AND ENERGY

During Session 2, three breakout groups were each asked to map the interactions between climate, public health, and energy resilience in Puerto Rico. Each group took a different approach, which is represented visually in Figure 4. Group 1 approached the mapping from a hazard’s perspective, locating environmental hazards like hurricanes and drought in the middle of upstream social drivers (to the hazard’s left) and key societal outcomes like nutrition and mental health downstream to the left. The map focused on the interactions between the different drivers, hazards, and outcomes. The dominant links flow in the direction of drivers-to-hazards-to-outcomes. However, the feedbacks are also identified, such as the role of temperature (heat waves or persistently above-average temperatures) on political will. Group 2 had a solutions and justice orientation. A more circular economy and equitable access to affordable energy (and resources) were the core values to uphold in the face of changing social and environmental conditions. Group 3 employed a combination of a hazard and a solution framing.

Despite the different ways of implementing the exercise, the participants found high degrees of connection between the domains of climate, public health, and energy resilience, including socioeconomic considerations that influence unequal impacts felt by different populations, and community education as a key factor influencing the resilience of the system. The three groups discussed their different approaches to mapping via presentations and, in plenary, further established a common perspective on the interactions.

The common perspectives, when paired with the knowledge of the CBO activities discussed prior in the workshop provided a platform from which to identify and discuss action and knowledge gaps needed to build resilience in Puerto Rico

Figure 4. Maps of the interconnections between climate, energy, and public health produced by three breakout groups: Group 1 (this page), Group 2 (page 18, top), and Group 3 (page 18, bottom). We show the maps to illustrative the patterns; the specific information on the nodes is not discussed in detail.



KNOWLEDGE GAPS

Three breakout groups during Session 3 focused on identifying knowledge creation opportunities to move toward solutions. The knowledge gaps identified in Table 3 largely describe gaps in knowledge awareness among the participants, and therefore relate to a need for more robust ways of connecting science to decision making. Gaps in the science base were also identified, providing opportunities for future research. This would include a need for research on engagement, information translation, and decision support with a community representative of those we engaged.

The knowledge gaps identified in Session 3 of the workshop fall into five categories.

1. Expanding research towards the development of a “circular economy.” Participants feel there is a need for more detailed studies and information about the life cycle of goods (including food) with attention to the comparative impacts of different consumption scenarios and more attention, in general, paid to the development of recycling strategies and technologies. This information is desired to help inform decision-making to create a less ecologically impactful and more circular, sustainable economy.
2. Supporting climate-adapted food systems. Participants see a need for research and knowledge dissemination related to climate-smart technologies, techniques, and strategies appropriate to sustainably cultivating food production and security in Puerto Rico’s changing climate.
3. Improving data on Puerto Rico’s population to inform more efficient planning. Participants understand that the lack of data in Puerto Rico makes it more difficult to make decisions and have more reliable statistics.
4. Building awareness of funding and other technical support. Participants feel that many NGOs, CBOs, farmers, municipalities, small traders, and other entities in Puerto Rico are not aware of the funds and other support available.
5. Advancing knowledge of psychosocial impacts of climate change. Participants recognize that climate change is related to mental health, nutrition, and emotional intelligence.

The full list of knowledge gaps is presented in Table 4.

Table 4.

Category	Knowledge Gaps
<p>Circular Economy</p>	<p>How can Caribbean Small Island Developing States integrate the circular economy; what can be learned from studying other Caribbean countries?</p> <p>What is the environmental cost of consumption (including externalities in production)?</p> <p>What are the benefits and value of ecosystem services in Puerto Rico?</p> <p>How can Puerto Rico's modify their diet to use local products more efficiently?</p> <p>What is the current carrying capacity under current and projected levels of consumption and waste management; how might this change in the future, and what are plausible opportunities for developing more sustainable behaviors?</p> <p>What is the relationship between consumption levels and quality of life in Puerto Rico (some for the taxonomy would be helpful, like the taxonomy of fundamental human needs developed by Manfred Max-Neef)?</p> <p>What are best practices for waste management in Puerto Rico?</p> <p>What is the ecological footprint of consumption and diet?</p>
<p>Food Systems</p>	<p>Where are different crops going to be grown in the face of changes in climate? For example, will there be different impacts on coffee and the regions of coffee cultivation? What "climate smart" techniques are available, such as new seed varieties adapted to climate change?</p> <p>What are "climate smart" techniques that can help in the cultivation and sustainability of important crops in Puerto Rico?</p> <p>There is a lack of knowledge about agroecology and permaculture.</p>
<p>Data for Planning</p>	<p>How can GIS information improve awareness of essential support services?</p> <p>How can we improve statistical data so that it is accessible, reliable, and at the community level? In what ways can data be converted to useful statistics?</p> <p>What consumer behaviors lead to adopting or rejecting climate adaptation activities, change such as a transition to solar panels?</p>
<p>Funding and Other Support</p>	<p>What are strategies and avenues to acquire financial support to prepare for disasters. This includes a better awareness of the available grants and funding sources for NGOs, CBOs, municipalities, farmers, small businesses, etc.</p> <p>More information is needed that explains how to officially register as an organization or a group of organizations.</p>
<p>Psychosocial Impacts</p>	<p>What are the interrelationships between climate change, mental health, food and emotional intelligence?</p>

ACTION GAPS

Breakout discussions during the final workshop session focused on identifying action gaps, which the group understood to be activities that are emphasized now as well as in the future to improve the island’s resilience to the joint risks of climate, public health, and energy. In total, the group generated 32 separate actions that we categorized into eight common topics. In a post-workshop survey, we asked participants to identify which of the 31 activities their organization currently has the ability and willingness to work on. Table 5 shows the frequency that each action was identified. In total, the 31 actions showcase the diversity of actions that, according to the workshop participants, need to be emphasized more on the island. The frequency at which the survey respondents identified each action further suggests those organizations that currently have both the ability and willingness to address those issues.

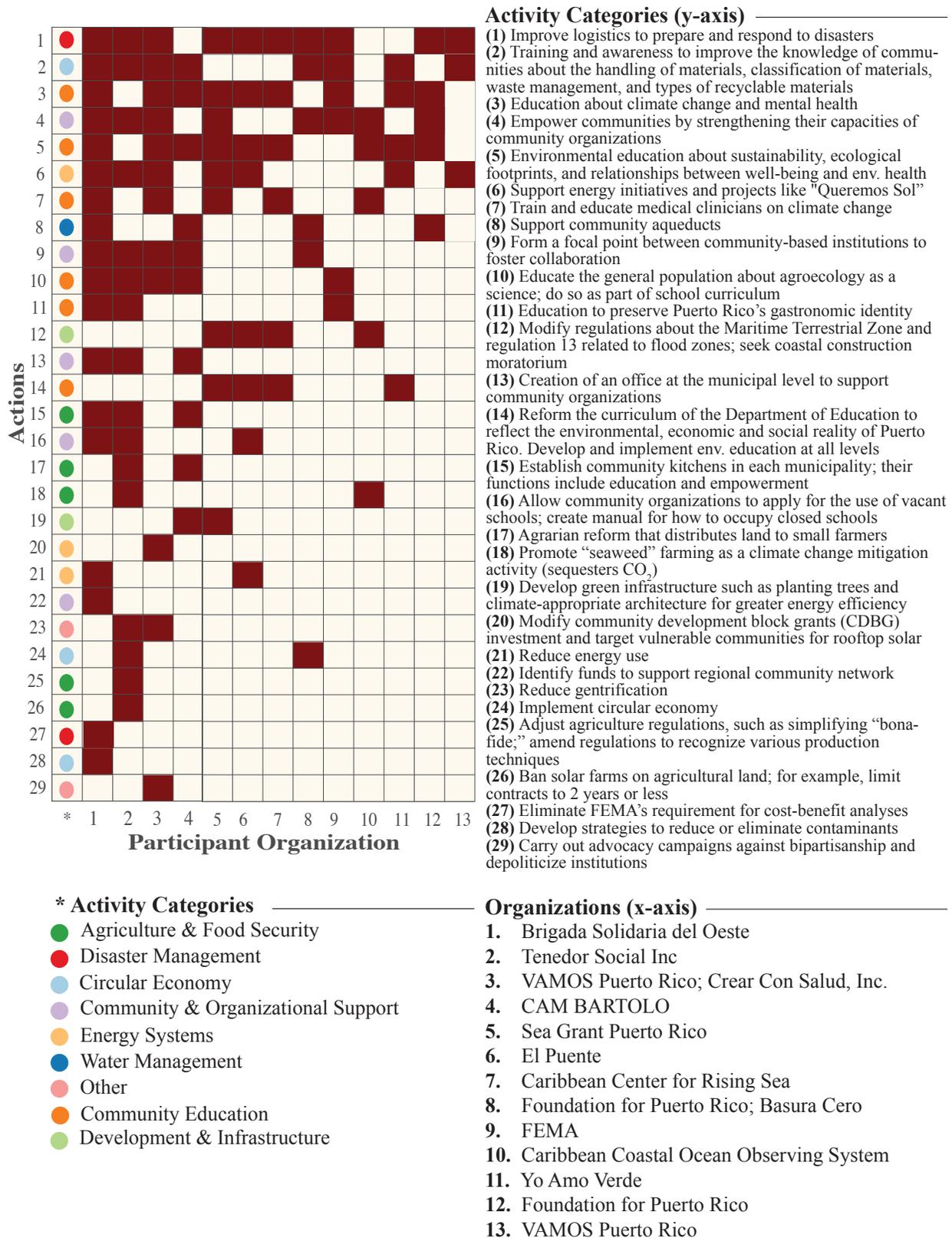
The participant responses to the action gaps also created clusters of organizations willing and able to engage in different actions. In this way, the exercise is a starting point to organize future collaborations. Figure 5 shows a heat map of 15 distinct organizations and the action gaps each identified. Importantly, the actions identified by the organizations do not represent the full spectrum of activities the organizations are currently working on or are interested in working on.

Table 5. The 31 action gaps identified in the workshop that we organized into 9 overarching categories. In a follow-up survey, 21 workshop participants selected the action gaps that their organization currently has the ability and willingness to work on, which are reported as # and %.

Action Gaps	#, %	Category
Develop and optimize community logistics (at the municipal level) to prepare for and respond to disasters. Focus on: (1) the distribution of aid, (2) the dissemination of information, (3) training of community members to implement emergency plans, and (4) strengthening community censuses to generate rapid response plans	11, 52%	Disaster Management
Environmental education on topics such as sustainability, ecological footprints, and the relationships between human well-being and environmental health.	9, 43%	Community Education
Education about climate change and mental health	9, 43%	Community Education
Empowering communities by strengthening the capacities of organizations	9, 43%	Comm. & Org. Support
Training and awareness to improve the community knowledge about material handling, material classification, waste management, and what materials are recyclable	9, 43%	Circular Economy
Support ongoing initiatives and projects such as “We Want Sun”	8, 38%	Energy resilience
Educate the general population on agroecology and integrate into school curriculums	5, 24%	Community Education
Training and education for clinicians on climate change	5, 24%	Community Education
Support community aqueducts	5, 24%	Water Management
Form focal points among community-based institutions to foster collaboration	5, 24%	Comm. & Org. Support

Action Gaps	#, %	Category
Community education to preserve the gastronomic culture of Puerto Rico	4, 19%	Community Education
Working through the Department of Education, reform school curriculums to better reflect the environmental, economic, and social reality; develop and implement environmental education at all levels	4, 19%	Community Education
Creation of an office at the municipal level to support community-based organizations	4, 19%	Community Education
Establish community kitchens in each municipality; its functions include resilience center training and empowerment of community leaders	3, 14%	Agr. & Food. Security
Evaluate shuttered schools so that community organizations can request the empty buildings; distribute manual for occupation of closed schools to community organizations	3, 14%	Comm. & Org. Support
Agrarian reform that distributes land to small farmers	2, 10%	Agr. & Food. Security
Promote “seaweed” farming as a climate change mitigation activity	2, 10%	Agr. & Food. Security
Modify regulation of Maritime Terrestrial Zone and regulation of flood zones; moratorium on coastal construction	2, 10%	Development & Infrastructure
Develop green infrastructure such as planting trees and climate-appropriate architecture for greater energy efficiency	2, 10%	Development & Infrastructure
Modify Community Development Block Grant Program and target vulnerable communities for rooftop solar	2, 10%	Energy resilience
Reduce energy consumption (e.g., more efficient systems, procurement of Energy Star equipment, etc.)	2, 10%	Energy resilience
Identify funds to support a regional network	2, 10%	Comm. & Org. Support
Reduce gentrification (public policy and advocacy)	2, 10%	Other
Implement a circular economy (creation of legislation, taxes on corporations, etc.).	2, 10%	Circular Economy
Adjust agriculture regulations, such as simplifying Bonafide farmer processes, and amend existing regulations to recognize various agricultural production techniques (such as “Bonafide”) to encourage and promote agriculture; simplify the application processes for agricultural permits	1, 5%	Agr. & Food. Security
Ban solar farms on agricultural land; limit contracts to 2 years or less	1, 5%	Agr. & Food. Security
Eliminate or adjust FEMA's cost benefit analysis; disaster response can be improved with a more holistic treatment of interacting risks and not just approach the issue from an economic cost-benefit perspective	1, 5%	Disaster Management
Carry out advocacy campaigns against bipartisanship and depoliticize institutions	1, 5%	Other
Develop strategies to reduce or eliminate waste and pollution	1, 5%	Circular Economy
Diversify energy sources	0	Energy resilience
Establish preventive measures for reservoir management	0	Water Management

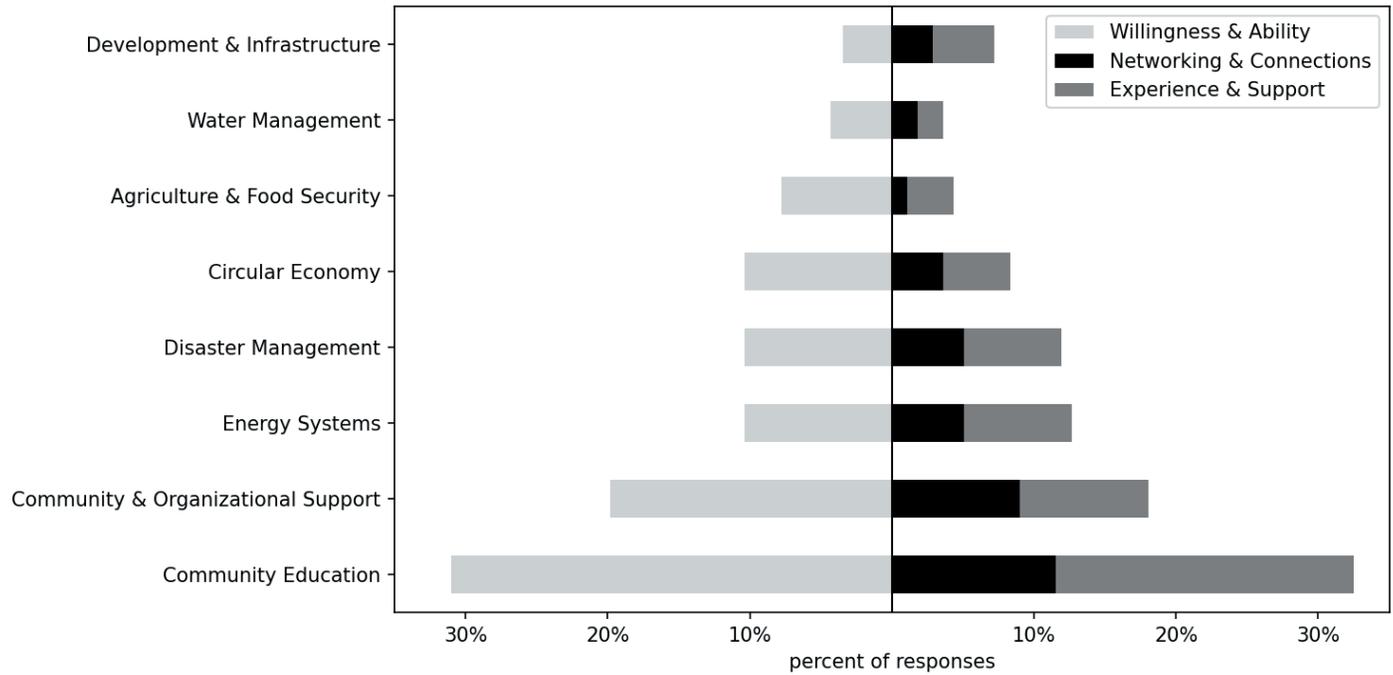
Figure 5. This figure displays the willingness and ability of different organizations (x-axis) to engage in the action gaps (y-axis) identified at the workshop. The figure identifies clusters of organizations and actions, providing a sense of potential partners to collaborate on future work. The colored circles donate the category of the actions. The action gaps were identified at the workshop, while the willingness and capacity to engage in the actions were obtained in the post-workshop survey. Only those action gaps identified at least once by the respondents are listed on the y-axis (29 of the 31 actions are reported).



We further asked the respondents to describe the resources they could bring to collaboration around the action gaps they selected. Using the eight categories, Figure 6 shows both the willingness and ability to engage in activities (on the left side) and the resources they could bring to that issue (on the right side). Resources are divided into “networks,” which involve participating in existing collaborations or having a sense of where to become more involved, and “capacity,” which involves bringing experiences, resources, or other skills to

the collaboration. The figure shows that education is the most emphasized both in terms of willingness and ability and in terms of the resources that can be brought to bear. The high level of resources and emphasis on coordination also suggest an environment where action can be realized. More traditional forms of hazard mitigation such as in infrastructure and water and food systems have fewer resources and engagement with this group.

Figure 6. Respondents of the post-workshop survey reported their willingness and ability to engage in activities identified at the workshop, which were grouped into eight categories (left side of figure), and the resources they could bring to bear on future collaborators around those activities (right side). The category “Other” is omitted; it contains only 3 responses (see Table 5).



CONCLUSIONS AND KEY MESSAGES

By way of conclusion, we stress six themes that emerged from our project.

A Moment of Opportunity. The activities detailed in these pages have built a base of knowledge and established new connections that create a moment of opportunity. “Good” engagement is built on trust and a shared sense of purpose. These qualities are hard won through routine iteration that incrementally builds community. This takes time. This project accomplished an initial step in this direction, identifying many issues that are intellectually and practically interesting to pursue. To name but one potential next step, the topic of climate change on mental health could benefit from organizing a working group to develop research on the impacts of disasters on mental health or to develop an effort that explicitly connects existing information about the topic to the public. It was clear that climate and mental health was a topic that many organizations were willing and able to work on (Figure 5).

A Solutions Frame. A second theme related to the way the participants re-framed our workshop toward solutions. The workshop had an initial hazards framing, which stresses the social and environmental interrelations that lead to risk. While this framing clearly resonated with both the planning committee and workshop participants, the end point of such a framing is often risk assessment. Rather, problematizing cascading and compound hazards can be a step in finding solutions, and not the end itself. While risk assessments are important, so too are solutions visioning. Knowledge gaps are thus an intermediary in the process of identifying actions to take. In this respect, the project left wanting inquiry on “how” to take action on the gaps identified. Developing “the how” as a next step supports our previous contention that ground has been laid to capitalize on a moment of opportunity.

Support for Collaboration Among Organizations. The representatives of the organizations we engaged are currently working on issues they perceive to address at the same time climate hazards, public health, and energy resilience. This creates opportunities for new collaborations and, importantly, new synergies. However, progress would be enhanced through “network” type support to create more, and more effective, collaboration. At the same time, the fact that many

ongoing are working at the intersections of multiple hazards suggests that local organizations are well positioned to be leaders on resilience whereby the ability to cope and transform in the face of diverse challenges are addressed holistically.

Connecting Existing Knowledge to Action. Many of the knowledge gaps identified are oriented toward building awareness. This includes information on how to register as an organization and best practices on climate-smart agriculture and waste management. These knowledge gaps point to an important need to bridge the distance between existing knowledge and action. To this end, two core insights emerge. First is a need to better disseminate insights from scholarly research to CBOs and other stakeholders in ways that can inform evidence-based action. The second is a need for more context-based research to translate general knowledge about, for example, waste management to the realities of the Puerto Rican context.

Broad Set of Interconnection. Some topical priorities such as circular economy, recycling, and agricultural resilience may not appear immediately to touch jointly on climate, public health, and energy resilience. However, concerns about land-use decisions between agriculture on the one hand and utility-scale solar on the other do have implications for all three of the domains. Likewise, questions about waste streams (e.g., composting and agriculture) or accumulated waste products from the obsolescence of household and utility-scale energy infrastructure) are entwined in larger questions about climate, health, and energy.

High Degrees of Collaboration and Willingness to Collaborate. It was clear that there is a lot of collaboration occurring in different, smaller networks and that there is a desire to bridge these networks. There exists a high degree of willingness to engage with many different action gaps, as well as a high degree of human resources and experiences that can be brought to bear on these collaborations. This emphasis on coordination suggests an environment where action can be realized.

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APPENDIX 1: Workshop Participants and Agenda

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Agenda

Planificación Colaborativa para un Puerto Rico Resiliente ante el Efecto Cascada en Clima, Energía y Salud Pública

Hora Sesión

8:00–8:30	Registro
8:30–8:50	Bienvenida y presentación del taller
8:50–9:30	Presentaciones: Descripción general del estado actual del conocimiento, el progreso y las direcciones futuras para abordar el clima y la salud pública y el clima y la energía en Puerto Rico- add footer to agenda
9:30–10:30	Sesión 1: Discutir las acciones que están tomando las organizaciones representadas para abordar el clima, la energía y la salud pública en Puerto Rico
10:30–11:00	Descanso
11:00–12:30	Sesión 2: Mapear y discutir las conexiones entre el clima, la energía y la salud pública- scour stuff at office
12:30–1:30	Almuerzo
1:30–3:00	Sesión 3a. Identificar oportunidades de acción y creación de conocimiento para avanzar hacia soluciones
3:00–3:15	Descanso
3:15–4:00	Sesión 3b. Construir una agenda de acción e investigación: priorizando las oportunidades de la sesión 3a
4:00–4:30	Clausura

Time Session

8:00–8:30	Registration
8:30–8:50	Welcome and workshop introduction
8:50–9:30	Presentations: Overview of current state of knowledge, progress, and future directions to address climate and public health and climate and energy in Puerto Rico
9:30–10:30	Session 1: Discuss the actions being taken by the represented organizations to address climate, energy, and public health in Puerto Rico
10:30–11:00	Break
11:00–12:30	Session 2: Map and discuss connections between climate, energy, and public health
12:30–1:30	Lunch
1:30–3:00	Session 3a: Identify action and knowledge creation opportunities to move toward solutions
3:00–3:15	Break
3:15–4:00	Session 3b. Build an action and research agenda: prioritizing opportunities from Session 3
4:00–4:30	Closing

APPENDIX 2: Workshop Program

Time	Session	Description				
8:00–8:30	Registration	<p>Coffee, light breakfast</p> <p>Registration: Registrants add to their name tag a colored stickier that denotes their principal focus of climate (blue), energy (yellow), public health (red). The stickies are used help organize sessions. The colored sticky should represent the thematic topic the registrant feels most comfortable speaking on behalf of.</p>				
8:30–8:50	Welcome	<p>Articulates the reason for the assembly and the goals and outputs of workshop. Reviews the program.</p>				
8:50–9:30	Framing presentations	<p>Purpose: The presentations provide guidance for the workshop discussions and help establish a common point of reference.</p> <p>Organizing committee members give two, 15-minute presentations. One discusses the significant issues in climate and public health and the other discusses climate and energy. The presentations address the issues are at the intersection of climate and public health and climate and energy, the state of the science about the issue, and future directions.</p>				
9:30–10:30	Session 1: What are organizations doing?	<p>Purpose: Understand the work organizations are doing related to the 3 topics. This session will identify where the opportunities and gaps exist (which we dive deeper into in session 3). This session has the added advantage of (1) providing space to the participants to talk about their work, (2) gain awareness about other organizations' work, and (3) begin building/strengthening network connections.</p> <p>Activity Format:</p> <ol style="list-style-type: none"> Participants split into smaller groups of no more than 10. Groups should have a diverse representation of the three main focus areas. Participants look at their colored dot on their name tag and self-divide based on a good mix. Have member of organizing committee at each table facilitate <i>(10 minutes to organize into groups and to explain activity through step 4.)</i> On notecards, individuals write 3–5 main activities they/their organizations are doing now or that they have done recently related to climate, public health, and/or energy access and security. <i>(10 minutes for this & step 3.)</i> On the other side of the note card, the person notes their organization name AND the main collaborators they work with (institutions) on that activity. <p>Example:</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td style="text-align: center; vertical-align: middle;">FRONT</td> <td style="padding: 5px;">Educating San Juan community on household heat adaptation via door-to-door visits</td> <td style="text-align: center; vertical-align: middle;">BACK</td> <td style="padding: 5px;"> Organization: Organization A Main Collaborators: Organizations B, C, and D </td> </tr> </table> <ol style="list-style-type: none"> Individuals place the note cards on a large pre-drawn Venn Diagram (we used a large 3.5 x 5 feet vinyl sheet). <i>(10 minutes.)</i> The facilitator leads a discussion to ask about the activities on the Venn Diagram, starting with the activities in the overlapping sections. <i>(30-minute guided discussions)</i> <p>Questions can include:</p> <ul style="list-style-type: none"> Tell us a bit about [activity]? What have been the benefits of [activity]? What have been the challenges of [activity]? How does this overlap with [health or energy or climate]? <p>Notetakers.</p> <ul style="list-style-type: none"> We will have one placed at each table to record details of the discussions <p>Learning Outputs:</p> <ul style="list-style-type: none"> What activities are ongoing, by whom, and why. How activities related to the three topics. <p>Output for Participants.</p> <p>Create an “address book” for participants, which will include:</p> <ul style="list-style-type: none"> Organization names, brief descriptions, locations, and contact information (from registration) 3–5 activities that each organization is working on Organizations they often collaborate with 	FRONT	Educating San Juan community on household heat adaptation via door-to-door visits	BACK	Organization: Organization A Main Collaborators: Organizations B, C, and D
FRONT	Educating San Juan community on household heat adaptation via door-to-door visits	BACK	Organization: Organization A Main Collaborators: Organizations B, C, and D			

Time	Session	Description
10:30–11:00	Break	
11:00–12:30	Session 2: Interconnections	<p>Purpose: This session will explore the inter-connections between climate, public health, and energy, with a focus on impacts, to develop a common understanding of how climate, public health, and energy affect each other.</p> <p>Activity Format 1</p> <p><i>Small-Group Exercise (30 minutes)</i></p> <ol style="list-style-type: none"> 1. Divide into new groups of no more than 10 people. Each group needs to have people who can speak on behalf of climate, energy, and public health. Ask the audience to self-divide, using the colored stickers placed on the name tags. Reconfigure group if one topic is not represented. 2. Within group, subdivide into climate, health, and energy working groups (should be 2-4 people per each group). Each group writes ~5 issues on the cards provided that are of main concern for that topic. <ul style="list-style-type: none"> • The climate people write down major climate hazard, like hurricanes, heat waves, Saharan dust. The energy and public health folks write down the main issues of each topic affecting the island. 3. Members at the table, as a team, locate the cards on the vinyl sheet (with scotch tape), drawing connections between them based on the provided (printed) legend. Smaller cards that are also provided can be used to briefly describe the nature of each connection (i.e. how are the two phenomena connect). <p>Note on materials: Larger cards will be used for the main issues, smaller cards will be used for the connection details, and wet erase markers will be used to draw the connections.</p> <div style="border: 1px solid black; padding: 5px; margin: 10px 0;"> <p>Map Connection Legend:</p> <p><i>Connection Strength</i></p> <p>Dotted line = weak</p> <p>Solid line = moderate</p> <p>Double line = strong</p> <p><i>Connection directionality:</i></p> <p>←, →, or ↔</p> </div> <p>Notetakers for each table.</p> <ul style="list-style-type: none"> • We will have one placed at each table to record details of the discussions. <p>Activity Format 2</p> <p><i>Presentations and Discussion in plenary (30-45 minutes)</i></p> <ol style="list-style-type: none"> 1. One representative from each small group presents their group's map in 5 minutes or less. 2. Facilitator guides brief plenary discussion of similarities and differences among the maps (Yasmin will continue to facilitate). Prompt questions can include: <ul style="list-style-type: none"> • What are some of the overarching similarities between the maps? • Are there connections or other details on these maps that you agree with but are not part of your group's map? • Are there connections on other maps that you see differently? Are there connections on other maps that you would represent differently? (provide time for the groups to respond to one another) <p>Notetakers in plenary.</p> <ul style="list-style-type: none"> • Take notes on the plenary discussion. <p>Learning Outputs of Session 2:</p> <ul style="list-style-type: none"> • Maps of interconnections between climate, public health, and energy as understood by and relevant to participants • Better understanding of different views of these interconnections <p>Concrete Outputs for Participants:</p> <ul style="list-style-type: none"> • Maps to be included in post-workshop summary concise report for participants
12:30–1:30	Lunch	

Time	Session	Description
1:30–3:00	Session 3: Opportunities and action and knowledge Gaps	<p>Purpose: Develop a common understanding of climate, health, and energy connections and use that common understanding to identify: (1) actions needed to contribute to a more resilient Puerto Rico, (2) opportunities for collaboration, and (3) where research can play a role in supporting action to fill the gaps.</p> <p><i>Creating a Consensus Map (30-45 minutes)</i></p> <p><i>Everyone comes together in plenary (but no sitting; its after lunch!). Using the maps created in session 2, the goal is for the group to create 1 version.</i></p> <ol style="list-style-type: none"> 1. During the break, the workshop organizing team (Sarah and any other interested volunteers) will take a blank vinyl sheet and start the consensus map based on the themes that the groups all agreed upon in Session 2. This will serve to kickstart the consensus map building activity and expedite it. 2. The facilitator focuses the group attention on this vinyl sheet and leads a large group discussion to create an map that the whole group agrees on. This is the “Consensus Map.” 3. Discussion will focus on Question 3 from the Session 2 discussion: “Are there connections on other maps that you see differently? Are there connections on other maps that you would represent differently?” <ul style="list-style-type: none"> • The facilitator will focus on each of the differences (or at least the major differences) that came out in that session 2 discussion and work to guide the whole group towards a mutually agreed-upon way to represent the interconnection in question. • As agreements are reached, they will be added to the Consensus Map. <p><i>Small Group Exercise to Identify Action and Knowledge Gaps (30-40 minutes)</i></p> <ol style="list-style-type: none"> 1. Small groups will coalesce at tables (again looking to get a good mix of people from climate, health, and energy) 2. Groups will be asked to look at the Consensus Map and identify key “action gaps” or actions needed to strengthen Puerto Rico’s resilience to these interconnected hazards. These action gaps will be written on a piece of Flip Chart paper at each group’s table (see below). The Venn-Diagrams from Session 1 will be displayed (if possible) so that groups can choose to reference these if they need a reminder of existing activities. 3. Groups will then be asked to think about what “knowledge gaps” exist, i.e. what further knowledge would be helpful to support the necessary actions that they just listed. These will be listed on a separate flip chart paper at each group’s table. <div style="display: flex; justify-content: space-around; margin: 10px 0;"> <div data-bbox="565 1230 902 1318" style="border: 1px solid black; padding: 5px; width: 200px;"> <p style="text-align: center;">Flip Chart Page “Action Gaps”/Actions Needed for a Resilient Puerto Rico</p> </div> <div data-bbox="959 1230 1297 1318" style="border: 1px solid black; padding: 5px; width: 200px;"> <p style="text-align: center;">Flip Chart Page “Knowledge Gaps”/ Knowledge needed to support Actions</p> </div> </div> <p><i>Placing the Gaps on the Map (15 minutes)</i></p> <ol style="list-style-type: none"> 1. Groups will be asked to write action and knowledge gaps on notecards and place them on the Consensus Map. This is important that that we have a record of where/what the actions and knowledge gaps pertain to. 2. Facilitator will ask groups to reflect on the Map and the way the actions and knowledge they described help to account for all of the hazards and connections they considered earlier. (If there is time, a few questions can be posed to the group to spur reflection ahead of the next session) <p>Notetakers for each table.</p> <ul style="list-style-type: none"> • We will have one placed at each table to record details of the discussions. <p>Outputs:</p> <ul style="list-style-type: none"> • Detailed notes on action gaps • Detailed notes on knowledge gaps
3:00–3:15	Break	

Time	Session	Description
3:15–4:00	Building Action and Research Agenda Priorities	<p>Purpose: Putting pieces together to understand group priorities for next steps concerning (1) research and (2) actions. This session makes sure that there is a large group discussion on what is covered in session 3 and that some preliminary consensus is reached by the group as per next steps regarding research and action.</p> <ul style="list-style-type: none"> • This activity sets the stage for further follow-up after the event. Facilitators will aggregate what is discussed during this session as Google Docs (one for the Action Agenda and one for the Research Agenda) and disseminate it to the group for further comments and edits virtually after the event. • These output documents could be shared across PR and to key decision-makers and other stakeholders on the island. This helps take the discussion from theoretical to practical and useful. <p><i>Agenda Prioritizing Activity:</i></p> <ol style="list-style-type: none"> 1. (All Action Gap flip chart pages and Knowledge Gap flip chart pages will be placed together on the wall. 2. Each participant gets 6 sticky dots. They will use 3 of their dots to indicate their top 3 priorities out of all of the action gaps listed. They will use the other 3 dots to indicate their top 3 priorities out of all of the knowledge gaps listed. (This will help us to see what the highest priorities are in the room) <i>(10 minutes)</i> 3. Facilitator will guide discussion <i>(30 minutes)</i> based on the distribution of dots. Potential discussion prompting questions could include: <ul style="list-style-type: none"> • X, Y, and Z were the highest priority actions, why did folks choose these? • A, B, and C were the highest priority knowledge gaps, why did folks choose these? • Based on what we discussed and what we all learned about each other’s expertise and existing activities, are there coalitions that you see would be helpful to build in order to achieve these actions? • Perhaps dig deeper into each of the highest priorities (how could this happen? Who would need to be involved? What time frame would be useful to think about this on?) <p>Notetakers in plenary.</p> <ul style="list-style-type: none"> • Take notes on the plenary discussion.
4:00–4:30	Wrap-up	

APPENDIX 3: A Blended Stakeholder Engagement Approach: Tradeoffs in Combining Remote and In-person Activities

Stakeholder engagement has become central to developing usable climate information (1) and a primary determinant of climate information use (2). The Corona Virus has, however, changed the complexion of engagement. Remote methodologies are becoming more common, supplanting some of the in-person interactions and dislodging to some degree a dominant “co-production” framework in climate adaptation. It remains to be seen if this change is for the better or for the worse. Stakeholder engagement professes many benefits, such as improving stakeholder learning and actions while also improving the quality and relevance of research (3). Methods like participatory workshops and scenario planning emphasized multiple and iterative in-person engagements to build the trust and rapport that is critical for engendering ownership, openness to share experiences, and social learning. Climate adaptation scholars routinely cite the benefits of in-person engagement as leading to more salience knowledge and bestowing higher levels of credibility in the knowledge and information produced, while also fostering legitimacy in the information by including diverse values and viewpoints (4). Undoubtedly, moving more towards virtual engagement brings tradeoffs to some of these benefits.

We analyzed our diverse engagement activities within the context of a climate adaptation research project that engaged a group of enthusiastic stakeholders to plan and lead a participatory workshop. The activities with this group occurred in person and over Zoom between September 2021 and August 2022. In what follows, we discuss our “blended” stakeholder engagement approach which draws from advances in pedagogy and learning that have undergone a similar remote, e-learning, shift since the late 1990s (5, 6). A blended stakeholder approach uses both in-person and remote activities in ways that attempt to both maximize the benefits and minimize the limitations of each.

Here, we articulate three points. One, the logic that informed how we developed the project’s activities. Two, the key elements that facilitated our progress towards milestones and deliverables. And three, tradeoffs we confronted with our blended approach. We summarize these experiences to provide practical insights for future research and practice, particularly as they relate to climate adaptation and services.

Contextual Factors at the Project-Level that Shaped Engagement

Six conditions shaped our project’s approach to engagement. First, the project was funded through the NOAA–Climate Programs Office under its Regionally Integrated Sciences and Assessment (RISA) program. Over the 25 years of RISA funding, the program has made remarkable contributions to the scholarship and practice of stakeholder engagement in climate and weather services. Use-inspired, stakeholder engagement assessment models were a starting point for the project. We implemented a project framework that centered on stakeholder engagement as the core objective, and we operationalized the engagement via co-designing a participatory workshop with a small stakeholder planning committee and then hosting a larger stakeholder workshop. We allowed the details of “how” and “when” the engagement occurred, as well as to what ends, to emerge from the engagement itself. Post-covid, however, the central challenge has become cultivating these qualities while operating at once in a context of more hesitation for personal contact but more openness and tools to engage remotely.

Second, the project had a short, 1-year timeline with limited funding. This meant we had to make the most of the time available, to ensure we had protocols in place that did groundwork during periods leading up to in-person engagement, and importantly, that those remote activities dovetailed with the ultimate goals of the project. Thus, the early project activities focused on identifying and refining the network of possible organizations with whom to engage. This ensured that we cast a wide recruitment and collaboration net and that we did ‘homework’ to inform personal communications with organizational representatives. All projects seek efficiency and thoroughness with due diligence. However, the short 1-year timeframe created a higher penalty for inadequate preparation.

Third, we focused on a multidisciplinary research topic that had not received much previous attention, especially at the intersection of these topics and their capacity for cascading and amplifying impacts. Consequently, our aim was to convene a group of stakeholders working on relevant issues, but who may not have worked together before, with a focus

on community-based organizations working island-wide. We recognized that climate adaptation efforts in Puerto Rico have historically focused on the urban population centers and engaged the “usual suspects.” This knowledge further informed an approach to use social network infrastructure that allowed us to widen our search, and strongly favored the inclusion of in-person events.

The newness and multidisciplinary of the topic led to a strategy to engage stakeholders who are well connected and trusted. The project team initially included members with a long history of research and engagement in climate impacts in Puerto Rico. Their understanding of local contexts helped identify and prioritize stakeholders while also safeguarding against missteps. Their reputational power was leveraged in the team’s recruitment for the planning committee and participatory workshop participants, while their local knowledge helped identify the collaborators and participants that would favor a productive workshop. The later expansion of the project team to include the workshop planning committee further widened the ability to filter workshop participants in ways that would limit contentious debates that potentially could limit progress at the workshop.

Fourth, the newness of the group favored using a well-recognized frame for the event. The recent experience of hurricanes Maria and Irma led us to use a “hazards” framing that emphasized cascading impacts. The hazards framing stresses that risks in the context of climate hazards involve interactions between natural (physical) and human

(behavioral) factors, as well as cascading chains of these factors that amplify or exacerbate the scale and severity of these impacts. This includes immediate impacts and the long tail of an event’s aftermath and recovery. A common framing would help both the planning committed quickly come to a common understanding of the project, which was essential given the 1-year duration of the project, and the participants at a singular event. Collectively arriving at a common frame of understanding is often considered an important determinant of ownership in a project. In a short project, we tried to jumpstart this process.

Finally, in November 2021, three months into the project, the omicron variant became the dominant COVID strain. It reinvigorated uncertainty about returning to normal life that was described as “creat[ing] havoc and impos[ing] high public health concerns at global level” (7). During routine team meetings, the research team discussed the challenges of sustaining projects remotely as well as maintaining collaborative connections despite travel restrictions, social distancing, and concern about covid risks and exposure. This further emphasized the utility of a blended approach as we progress towards project objectives despite some uncertainty about future face-to-face interactions. The uncertainty meant required flexibility and scenario planning. A plan for having remote activities as part of the engagement design thus baked-in options if travel and social contact restrictions resurfaced. Ultimately, the societal response to Omicron did not lead to limited interactions.

Table 1. Main strengths and weaknesses of in-person and virtual/remote modes of engagement. The lists are theoretical and general. The degree of the strengths and weaknesses depend on the specifics of project execution.

	In-Person	Virtual/Remote
Strengths	<ul style="list-style-type: none"> • Builds rapport and trust • Allows addressing sensitive topics • Enables social learning • Efficiently builds common understanding • Creates dedicated time to focus • More flexibility in designing participatory activities • Attends to power dynamics 	<ul style="list-style-type: none"> • Reduces financial costs in personnel time and travel costs • Remote events are easier to attend • Lower travel, cost, and time demands overcome barriers to access, addressing equity issues • No physical “venue” limitations (e.g., attendee restrictions) allows for more involvement
Weaknesses	<ul style="list-style-type: none"> • Time intensive • Travel costs can be high • Reinforcing power asymmetries 	<ul style="list-style-type: none"> • Active participation is more difficult to facilitate • Remote participation competes with other on-going activities • Take longer to arrive at common understanding, if sought • Types of activities are more restricted • Depends on technology that can be exclusive

Table 2. Project activities and their corresponding methods and format.

Activities	Methods	Format
Needs assessments of organizations & institutions	<ul style="list-style-type: none"> Conducted 21 semi-structured virtual interviews. 	<ul style="list-style-type: none"> Virtual
Workshop co-design	<ul style="list-style-type: none"> Host 1-day meeting in San Juan with 4 planning committee members and 3 research team members. Convene 7 workshop planning meetings. 	<ul style="list-style-type: none"> In person Virtual
Participatory workshop & follow-up	<ul style="list-style-type: none"> Host 1-day workshop with 29 attendees. Administered post-workshop web survey. 	<ul style="list-style-type: none"> In person Virtual
Research Team Meetings	<ul style="list-style-type: none"> Five research team members met weekly. 	<ul style="list-style-type: none"> Virtual

A Blended Engagement Approach: In-person and Remote Activities

The impetus to study our project’s engagement was based on how researchers were adapting their activities during the covid pandemic, including a noticeable shift to remote meetings and asynchronous activities. We describe below the tradeoffs in an engagement approach that was not entirely based on in person activities but also not limited to virtual meetings, but engaged in a blended engagement model (5, 6). In theory, each mode of engagement has a set of strengths and weaknesses (Table 1). The strengths of in-person activities relate more to the social, emotional, and instrumental elements, whereas the strengths of the virtual/remote activities relate more to administrative elements, and vice versa. The degree of the success of the engagement depends on maximizing the social, instrumental, emotional, and administrative elements of the engagement.

In the final accounting, our project’s engagement activities were diverse (Table 2). The types of activities, their sequences, and their frequencies emerged from both the research team meetings as well as the workshop planning committee meetings. The central question our research team discussed during these conversations was how to maximize the benefits associated with remote activities, while minimizing the loss incurred by not engaging in in-person activities.

Trade-offs

Our blended approach sought engagement that was both wide and deep. An approach based on in-person activities emphasizes depth over breadth, whereas remote activities trade in-depth exploration for scale. We attempted to reach a broad audience in the network development phase

when it was crucial to account for stakeholders who were working across the island and not the “usual suspects.” We considered two strategies: A set of smaller, in-person workshops and remote interviews. We opted for the latter because it helped us break out of the well-worn path of established but siloed connections, where the usual stakeholders are enthusiastic and attend meetings and workshops, but that can overlook stakeholders not part of these established networks. This was a critical decision because a goal of the project was to be inclusive and to avoid marginalizing less prominent actors. We therefore built a database from the ground and used remote techniques to seek interviews with an array of stakeholders. Furthermore, the remote interviewing allowed us to adapt to schedules, iterate on our interactions if the first contact pointed us to more relevant actors, and encouraged us to explore the network to ensure a diverse representation. The downside to this “wide” engagement was to place considerable workload on our Puerto Rico-based project team members. We ultimately implemented a deep approach by convening two in-person events, the small planning committee meeting, and the participatory workshop.

A second challenge was to strike a balance between a comprehensive inventory of the stakeholder network and one constructed from a convenience sample of those our team knew would be excellent partners and collaborators. Our efforts to catalog the network did not lead to an exhaustive database. This was beyond the limits of our time and resources. However, our local knowledge recognized that the database had assembled many known actors but not all the known actors, and we supplemented other known actors who were missing. Ultimately, we were not able to engage comprehensively across the island geography, and with every possible organization or regional group

working on issues related to climate, public health, and/or energy. Rather, for pragmatic reasons of project timeline, budget, limits on workshop capacity, we interviewed 21 organizations. The main implication for the middle ground we staked between a network consisting of known entities (e.g., a convenience sample) and a comprehensive network was to admit some degree of imbalance and lack of representation. We lacked the systematic focus that an island-wide survey provides, although we would argue that we had much more in-depth engagements than such a survey offers. While remote engagement can reduce a lack of “representativeness,” it requires setting reasonable expectations of response rates, the number of stakeholders engaged, and what constitutes success.

A third tradeoff relates to the use and accessibility of technology. With a blended approach, especially in the early days of network identification and actor recruitment, we used official records and web information to build the database, and remote communications including email, phone, and social media for early and iterative interactions with potential stakeholders. Our team did some follow up to reach out to groups that might not be represented in this first pass of information gathering, but it was a necessary part of a one-year scoping project to recognize the limits of this approach, while still meeting the main priorities of identifying the network and assessing its priorities. The reality is there are numerous neighborhood and non-governmental organizations, with a large proliferation after Hurricanes Maria and Irma in 2017. While some of those organizations show up in public databases, these were the challenging groups to contact, especially for those organizations that do not have a web presence. In-person fieldwork and networking, particularly in a longer-term project with time to travel and engage with wider networks would likely have more success reaching more “on the ground” organizations, some of whom may not be as easily contacted via remote, web methods.

Finally, despite successes with a blended approach in recruiting and developing the workshop, the planning committee was relatively adamant that the workshop was run as an in-person event (i.e. not hybrid or online). There was a strong sense that everyone in the same room would provide the best engagement, and that there had been too many zoom meetings over the past few years, not to mention a general desire to meet with colleagues in person again. This was beneficial for those who have resources to travel locally, but those that could not travel to the workshop locally, and non-PR-based team members who did not travel to PR for the

workshop, were not able to participate. The planning and follow up activities of the workshop (summarizing the information, a follow up survey related to action and knowledge gaps, etc.) – extended the ‘sustained’ model of engagement to bridge some of these gaps. This made it clear this was an ongoing process and dialogue, and not a single workshop that would define all the relevant questions and priorities or provide all the answers. Indeed, one of the principal deliverables coming out of this year-1 scoping process is a lengthy list of groups and their activities and their motivation to work on various priorities based on gaps and needs identified before/during the workshop. Rather than purporting to provide the answers, this project, and the sustained engagement process, is a tool to develop a refined set of questions that resonate with local stakeholders, and which lays out some initial directions where future collaborations could leverage existing work and resources, or that would be particularly responsive to a widely recognized need.

Key Takeaways and Future Directions Blended Stakeholder Engagement.

Our reflections on our blended approach are in service of informing projects with similar aims and goals. One takeaway is the value of using the project phases to draw out a wider network of participants, starting with a relatively wide net, and using local knowledge and referrals to filter and refine our search and networking activities. This is, in some ways, akin to being shown around a new field-site by a key collaborator, who is introducing you to possible partners. Perhaps more importantly, the wider net meant a more diverse set of participants, including those that grew into a collaborator role based on knowledge and enthusiasm. This required a dedicated and focused effort to expand the network, to ensure that we moved beyond any well-worn collaborative paths to engage with novel stakeholders and geographies, and that were responsive to the needs and priorities they expressed. It also highlighted the importance of local partners on the project team, with a recognition of the workload that is inevitably asked and/or expected of them.

Another takeaway is the challenge of fully replacing in-person engagement with remote/zoom interactions, especially when it comes to the final workshop stage. The stakeholder network engagement and recruitment, and the planning meetings with key collaborators in the planning committee, were generally remote with some limited in-person meetings. The final workshop was in person, and while we documented the dynamic conversations from the activities in digital form,

the in-the-room, face-to-face conversations were critical to this process of moving forward and being successful.

A final takeaway relates to a need for more insights and guidance on blended approaches to stakeholder engagement. Some bodies of knowledge have been studying the strategies that lead to success. E-learning is one such field and its lessons learned and tradeoffs on virtual education would be valuable for informing climate adaptation and service projects. At the same time, however, there is a uniqueness to climate adaptation and services that require a tailored learning agenda. We offer as a starting point five research directions that emerged from reflecting on our blended stakeholder engagement approach.

1. Research that provides empirical evidence that compares outcomes of remote, hybrid, and in-person engagement. This could be accomplished through self-reported assessments from participants or quantitative surveys that compare groups subject to different engagement styles.

2. Research that explores the justice, equity, and diversity implications of remote, in-person, and hybrid approaches to stakeholder engagement. The research could explore how inclusivity changes with the approach, specifically documenting the demographics of participants in activities that are fully remote, hybrid, and in-person.
3. More explicitly evaluations of the tradeoffs between different engagement modes that include isolating
4. Social network analyses that document the connectivity and overlap of project participants and stakeholder networks for remote, hybrid, and in-person projects
5. Assessment of the utility and value of using asynchronous engagement and supplemental materials in advance of in-person events (i.e., workshop content, socializing virtually, pre/post surveys, etc.)

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