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Perspectives on climate information use in the Caribbean

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Within research on climate information for decision-making, localized insights on the influences of climate information use remain limited in small and low-income countries. This paper offers an empirical contribution on Caribbean perspectives of climate information use considering current barriers and enablers in the region. We employ thematic analysis of 26 semi-structured interviews with region-focused sectoral experts (including end-users and decision-makers) drawn from climate adaptation, disaster risk reduction, and resilience focused initiatives and institutions. The results reaffirm presence of known barriers, such as the crucial role of finance, but notably we identify a range of interlinked enabling and catalyzing conditions necessary for the effective use of climate information. These conditions include the need for island- and sector- contextualized climate information, the role of international donors, the importance of adequate human resource capacity and presence of loud voices/climate champions, as well as the need for effective political and legislative mandates and for greater co-production. We construct a visualization of respondents' understanding of influencing factor interrelationships. This shows how their heuristics of climate information use for decision-making intricately link with roles for proactive climate champions, and that available finance often reflects donor interests. We end by discussing how these insights can contribute to strategies for more effective climate information use to promote resilience within the region.

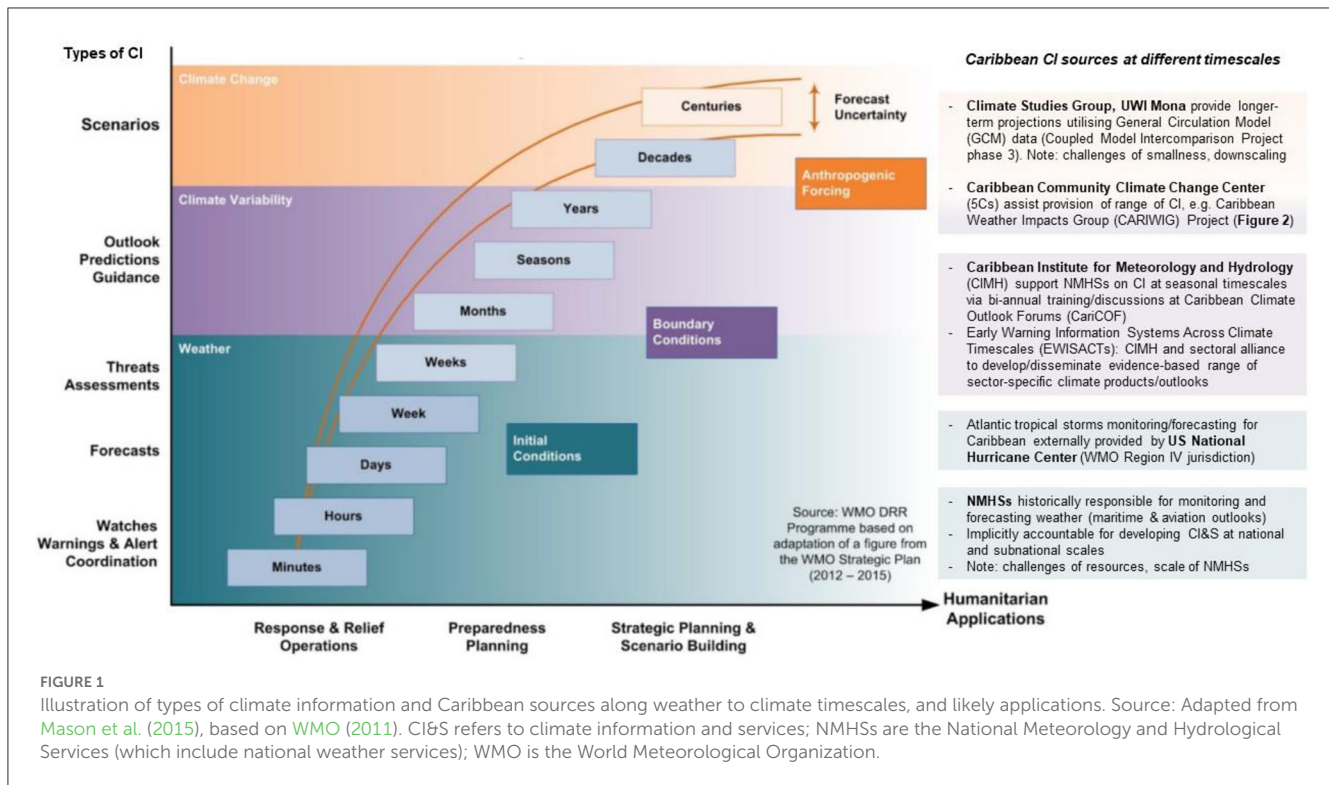
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climate information, resilience, Caribbean, barriers and enabling factors, local perceptions

1. Introduction

Improving the context of and decisions made regarding adaptation and resilience requires a wide range of conditions and actions. For instance, programs in understanding and planning for risks, as well as mobilizing climate finance, have been put forward by dialogues including the Paris Agreement, the Climate Adaptation Summit in January 2021, and the Global Commission on Adaptation (GCA, 2019; UNEP, 2021). Depending on context, a critical element of this process may be integration of information about climate risk into local decisions (WMO, 2007) supported by understanding of the availability, dissemination and usability of weather and climate information.

Weather and climate information is an amalgam of processed data, products and/or evidence-based knowledge about the historical, current, and future climate conditions in a specific location covering various timescales (Figure 1) (Dinku et al., 2011; Lemos et al., 2012; Mason et al., 2015; Singh et al., 2018). A focus on information *vis-à-vis* data “implies that it has meaning and relevance within a given context” (Singh et al., 2018, p. 390), noting that climate information may complement existing local and traditional knowledge. Climate information is an important element of the design and implementation of climate



risk management (Chen et al., 2021; New et al., 2022), although its characteristics and level of uptake vary with different approaches. Effective climate information use can support improved risk assessment based on enhanced temporal and spatial predictions (Dinku et al., 2011). At short timescales, locally relevant climate information including weather forecasts can inform preparedness planning, early warning systems, and response and relief operations within a disaster risk reduction (DRR) remit (see Figure 1). At medium-to-longer timescales, products such as outlooks, predictions and climate scenarios can assist resilience and anticipatory adaptation by identifying potential risks, and guiding investment and planning decisions (Jones et al., 2017).

To narrow the gap between climate science and adaptation action (Kirchhoff et al., 2015), a plethora of research has stressed the importance of tailoring climate information for decision-makers (Goddard et al., 2010; Kirchhoff, 2013; Knapp and Trainor, 2013; Singh et al., 2018; Orlove et al., 2020). This includes using dialogues with decision-makers (Vaughan and Dessai, 2014; Vaughan et al., 2018), considering usability (Dilling and Lemos, 2011; Lemos et al., 2012; Kalafatis et al., 2015), and promoting knowledge-action systems (i.e., comprehensive networks focused on advancing climate change adaptation products and services according to their impact and success) (Weichselgartner and Arheimer, 2019). As well, climate information is often discussed in tandem with climate services (Hewitt et al., 2012, 2017; Lourenço et al., 2016; Chen et al., 2021; Ranasinghe et al., 2021; New et al., 2022), i.e., activities focusing on generating and providing climate information to support ex-ante decision-making and climate-resilient development (Vaughan and Dessai, 2014; Ouédraogo et al., 2018).

Despite this awareness, there remain stubborn challenges to the mobilization and uptake of climate information, especially in climate-vulnerable, including small and low-income, countries (Jones et al., 2017, 2018; Harvey et al., 2021; New et al., 2022). Specifically, there is limited comparative and contextualized evidence for some countries, including Caribbean small island developing states (SIDS), in contrast to, for example, Europe (Porter et al., 2015; Bruno Soares et al., 2018; and sub-Saharan Africa: Vincent et al., 2020; Harvey et al., 2021). To address this research gap, we consider three questions relating to the current context of climate information use in the Caribbean: (1) how are the concepts of disaster risk reduction, adaptation and resilience in relation to the different timescales of climate-related decisions understood within the region?, (2) how are localized perspectives of available sources and current use of climate information manifested?, and (3) what are the perceived barriers and enablers of climate information use?

Recognizing the importance of local context and understanding, in this article we examine these questions with 26 Caribbean-focused respondents, including end-users and decision-makers, who work in a variety of climate-related sectors. The paper reviews their experiences and perceptions and focuses on how this information could be better contextualized for more effective use within the region. We offer thoughts on the support needed to reduce barriers and encourage enablers of climate information use, within the wider context of climate-resilient development. We note that since this research captures only a sub-set of perspectives the findings are intended to serve as indicative and a starting point for regional awareness and dialogue.

2. Framing the context of climate information use within the Caribbean

Taylor et al. (2016, p. 172) state that “*climate sensitivity* is both interwoven into and entrenched in all levels of Caribbean existence.” Although not a homogenous group, Caribbean countries feature broad similarities of physical characteristics, including geographical location, land area and topography. These feature alongside parallels of socio-economic and political aspects relating to small population sizes, economic dependency on climate-influenced primary industries, developing economic and governance systems, institutional legacies, high reliance on imports, and broad susceptibility to climate and non-climate-related shocks (Briguglio, 1995; Barnett and Dessai, 2002; ECLAC, 2011; Robinson, 2017; Thomas et al., 2020; Dookie and Osgood, 2021b). Such sensitivities, in turn, contribute to the reality of vulnerability to climate variations. While we note that there are diverse descriptions of *Caribbean*, from a geographical and ecosystem-based perspective, and as a region encompassing the Caribbean Sea basin and its bordering insular and coastal areas (Debels et al., 2017), we situate this study within the geopolitically aligned Caribbean Community (CARICOM) countries. In addition, we refer to Caribbean Small Island Developing States (SIDS) as a group of countries that face unique social, economic, and environmental vulnerabilities (UNOHRLLS, 2021), though recognizing the increased focus on the wider *small islands* contexts in gray and academic literature (Mimura et al., 2007; Nurse et al., 2014; Petzold and Magnan, 2019; Mycoo et al., 2022), as well as the Commonwealth Secretariat’s attention to *small states* (Commonwealth Secretariat, 2021).

Historically, Caribbean countries have been heavily impacted by short-term climate variability and extreme weather events including numerous flash floods, droughts, and tropical storms (Pelling and Uitto, 2001; Dookie and Osgood, 2021b), as well as effects of seasonal and inter-annual phenomenon such as the El Niño-Southern Oscillation (Giannini et al., 2000). In some instances, due to the interaction between hazard events and the location’s vulnerability (or propensity to be harmed), there have been *disasters*, with short- and long-term outcomes through human, material, economic and environmental losses, and impacts (Pelling et al., 2002; Rasmussen, 2004; Hochrainer, 2009; Hsiang, 2010; Hsiang and Jina, 2014; Hallegatte, 2015; Dookie and Osgood, 2021a). Given these outcomes, the need to reduce existing and prevent new disaster risk has been and remains important in national and regional capacity building efforts (Dookie and Osgood, 2021b), objectives which can be traditionally encapsulated within the concept of *disaster risk reduction* (DRR) (UNDRR, 2023). Further, the ongoing impacts and future threat of climate change within the region continues to drive the need for longer-term decisions and policy on adaptation (Giordano et al., 2020). Generally referring to “adjustments in ecological, social or economic systems in response to actual or expected climatic stimuli and their effect,” *adaptation* can come in many forms and is considered “a critical component of the long-term global response to climate change to protect people, livelihoods and ecosystems” (UNFCCC, 2023). As Caribbean countries look toward the future, the need to build robust or resilient capacity

to withstand further potential threats is essential. As such, using an increasingly common concept within the scientific and policy community, regionally and globally, *resilience* can be seen as “the capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure while also maintaining the capacity for adaptation, learning and transformation” (Ara Begum et al., 2022, p. 134).

Although these concepts are familiar and frequently used, they should be treated with caution as they may simplify broader discussion on their tenets and evolution of use. To assist, Rajabi et al. (2022) offer a historical narrative literature review of the concept of *disaster risk management* (DRM), which has evolved from mostly post-disaster response to a systematic and comprehensive risk management process with activities focused on four stages of mitigation, preparedness, response, and recovery. The terminology from UNDRR (2023) offers context on the distinct types of DRM and situates DRR (which includes prevention and mitigation) as the policy objective of DRM; a related term, *disaster management*, refers to the “organization, planning and application of measures preparing for, responding to and recovering from disasters”. While the above definition on climate change adaptation (CCA) from the United Nations Framework Convention on Climate Change (UNFCCC) is commonly referred to, we are aware of the broader discussions of this structure and the reflections on bringing the two sectors together. Although the concepts of DRR and adaptation may appear separate due to different international frameworks and spheres of action such as the long-term Paris Agreement and the Sendai Framework for Disaster Risk Reduction 2015–2030, there may be many similarities (Mercer, 2010), with a fundamental element of both being the motivation to reduce vulnerability and improve resilience (Kelman et al., 2015; Schipper et al., 2016; Kelman, 2017). The separation of climate change from wider contexts of DRR, as well as sustainable development, seems “counterproductive” (Kelman et al., 2015) and embedding climate change adaptation into DRR would serve a better purpose of enhancing the climate-related disaster resilience process (also see Thomalla et al., 2006; Dwirahmadi et al., 2013; Mercer et al., 2014; Schipper et al., 2016; Kelman et al., 2017; Islam et al., 2020; Flood et al., 2022; Nemaokonde and Niekerk, 2022). We highlight that the knowledge on CCA may also require further consideration in the context of adaptation heuristics (Nalau et al., 2021), which is defined as “common sense, rule[s] of thumb guiding the conceptual framing of adaptation, the prioritization of adaptation policies and measures, and/or the pathways by which they are implemented” (Preston et al., 2015, p. 469), as well as “adaptive capacity” (Robinson, 2018; Nalau and Verrall, 2021). Lastly, the complexity of resilience as a concept needs to be considered. Once mostly considered as the opposite of vulnerability, the term resilience has evolved etymologically and conceptually, temporally and across disciplines (Graveline and Germain, 2022).

Appreciating the context of these concepts, we may understand their roles in shaping approaches to resilience in the Caribbean. Noting an estimate of the economic impact of climate change within the region from 5.6% to 34% of gross domestic product (Pulwarty et al., 2010), the region has taken formative action to understand and mainstream adaptation to climate change into

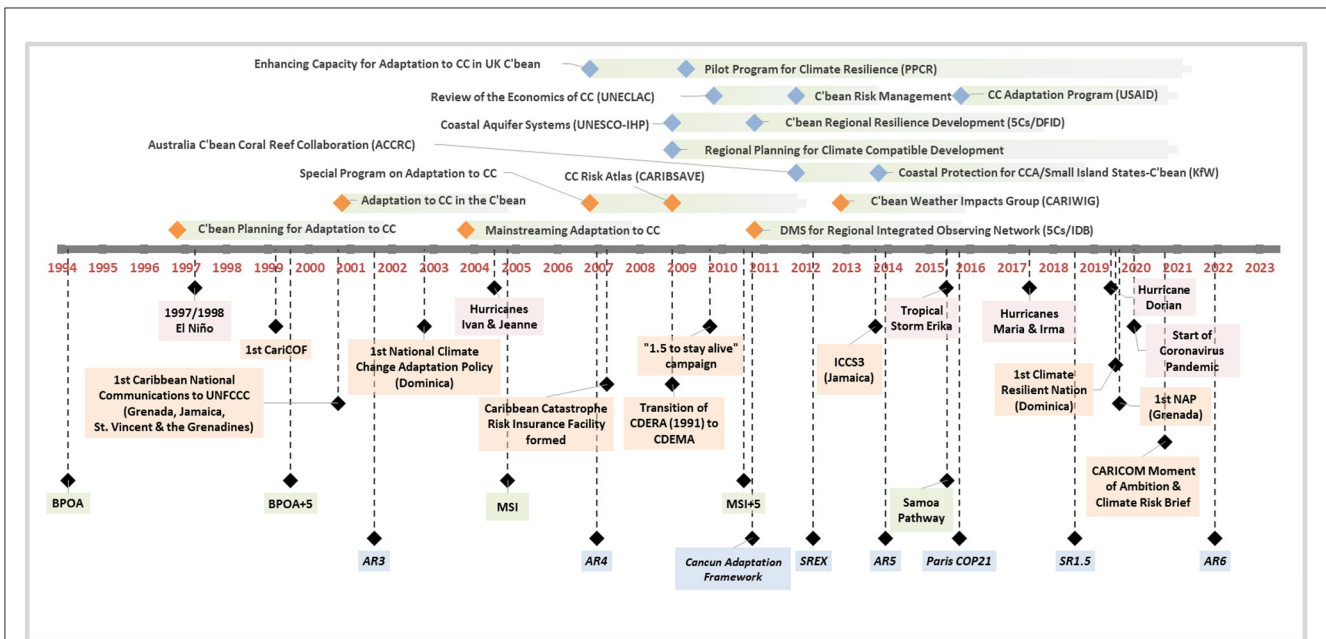


FIGURE 2
 Timeline of Major Caribbean Projects relating to Adaptation, and Climate Information and Services, 1994–2022. The top portion of this timeline highlights the periods of adaptation-related Caribbean programs and projects, as found on the Caribbean Community Climate Change Centre (5Cs) website (<https://www.caribbeanclimate.bz/>) as of January 4th, 2021, with projects offering scope climate information and services denoted with orange bullets. The bottom portion indicates a range of pivotal events and key milestones, such as: national actions [including the submissions of the first National Communications and National Adaptation Plan (NAP) to the United Nations Framework Convention on Climate Change (UNFCCC)]; regional events [including the first Caribbean Climate Outlook Forum (CaricOF)]; SIDS-related strategies [including the Barbados Programme of Action (BPOA) and Mauritius Strategy of Implementation (MSI)]; and international events and reports featuring SIDS [including the Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report (AR3), Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX), Special Report on Global Warming of 1.5 °C (SRI5), and the 21st session of the Conference of the Parties (COP) to the UNFCCC in Paris].

national strategies and build local adaptive capacity and resilience (Tompkins, 2005; Pulwarty et al., 2010; Birch and Simpson, 2011; Robinson, 2018; Thomas et al., 2019). This is reflected in a variety of regional/sub-regional donor-funded programs and projects, as noted on the website of the CARICOM Climate Change Centre (5Cs), as well as National Communications and National Adaptation Plans to the United Nations Framework Convention on Climate Change (UNFCCC) (see Figure 2).

A review of limits to adaptation in Caribbean SIDS highlighted persistent issues of finance and organizational capacity at the forefront of challenges, with technical capacity, data, human resources, and understanding of climate effects hindering national-level adaptation (Robinson, 2018, see also Betzold, 2015). Operationalization of a longer-term focus on climate has been limited due to challenges of regional fragmentation, prioritization of current and shorter-term issues, and dependency on externally driven institutions, ideas, capital, and skill (Bishop and Payne, 2012). This is noted in a context where the “climate agenda in the region is almost wholly dependent upon multilateral institutions and international NGOs for impetus, finance and expertise” (Bishop and Payne, 2012, p. 1549). While there are nuances and differences across Caribbean countries, with some (including Dominica, St. Lucia, and Jamaica) currently showing more focus than others, it is important to note that an assessment of 89 adaptation planning documents from Caribbean countries highlighted that adaptation planning and appraisal is a recent focus

within the region with room for much improvement (Thomas et al., 2019). This has created requirements for longer-term systemic planning across society (Rhiney, 2015), with implications for the demand for and use of relevant climate information.

There has been an increasing effort within the region to develop, disseminate and utilize climate information. As shown in Figure 1, there is a range of Caribbean-centered climate information sources available across diverse types and various timescales. The development of short-term weather-related climate information has been primarily within the domain of National Meteorological and Hydrological Services (NMHSs) in Caribbean nations (Mahon et al., 2018, 2019; CDB, 2020) with early responsibility of monitoring and forecasting weather for maritime and later aviation outlooks. Such information is largely utilized within watches and warnings as well as forecasts helpful for disaster response and relief operations (Guido et al., 2016, 2020; Dookie et al., 2019; Mahon et al., 2019; CDB, 2020; Wilkinson et al., 2021). With World Meteorological Organization-directed jurisdiction for the Caribbean region, the United States National Hurricane Centre assists in reconnaissance, monitoring and forecasting necessary for understanding tropical cyclone threats within the region, building further knowledge critical for preparedness planning. The regional Caribbean Institute for Meteorology and Hydrology (CIMH) operates at the boundary by supporting NMHSs with sub-seasonal (i.e., around 2 weeks to 2 months) and seasonal climate information in the form of regional climate outlooks including Temperature

and Precipitation Outlook Maps, the Drought Outlook, the Wet Days and Wet Spells Outlook, and the Experimental Dry Spell Outlook (CIMH, 2018; Mahon et al., 2018; CDB, 2020). They also provide guidance through projects such as Early Warning Information System Across Climate Timescales (EWISACT) and outputs such as the Caribbean Climate Outlook Newsletter, and offer training on tools at their bi-annual Climate Outlook Forums, which collectively assist strategic planning and scenario building. Longer-term climate information in the form of climate scenarios is often the focus of the Climate Studies Group at the University of the West Indies, Mona, Jamaica. While this group aims to provide details of longer-term projections utilizing General Circulation Model data, it is noted that, as small islands, the Caribbean faces challenges relating to downscaling (UNFCCC, 2007; Campbell et al., 2011; Karmalkar et al., 2013; Stephenson et al., 2014; Taylor et al., 2016; CDB, 2020; WMO, 2020). As the coordinator of the Caribbean's response to climate change, the CARICOM Climate Change Centre (5Cs) situates itself as a resource hub on climate change efforts and serves as the executing agency for projects related to climate change (Rosenberg, 2020). In Figure 2 we also highlight all regional/subregional adaptation-related projects cited on the 5Cs website, noting that 7 of 17 referenced projects specifically reference climate data and information.

Based on these sources, it is considered that “there is a sufficiency of knowledge on which to premise in response to the climate change threat, where action is a must and not an option” (Taylor et al., 2016, p. 193). However, there are few regional studies which focus on whether that knowledge is being used and what may be the ongoing influences, barriers, and enablers. As such, a wide user-driven understanding of and reflection on the demand, mobilization, use and uptake of climate information within the region could be insightful. We note that such an understanding may encompass user experiences on climate information (i.e., their practical contact with and observation of facts or events), their perspectives (i.e., points of view or attitudes toward or way of regarding something), and perceptions (i.e., intuitive understanding, insight, and interpretation). Complementary research on user experiences, perspectives, and perceptions of climate information within the region is noted in Mahon et al. (2021), which analyzed the insights of tourism sector-focused respondents on the use, sources of, and barriers to using weather and climate information, as well as Stewart-Ibarra et al. (2019) which looked at the role of climate/weather data on the public health sector. Although these studies are sector specific, they highlight the importance of knowledge which “facilitates a better understanding of who uses what, how and why, and for what group of users tailored climate information could make the most difference” (Mahon et al., 2021, p. 4).

Given the current availability, it is unlikely that an increased quantity of climate information is a solely sufficient condition to ensure climate information use and uptake. Rather, there will likely be a range of factors that influence the use of climate information. As such, user-led insights can assist our contextual understanding of these influences and may offer useful entry points for interventions and cost-efficiencies of operational learning which can specifically help resource-scarce regions

such as the Caribbean (Mahon et al., 2021). They may also shed light on possible challenges of the “who” and the “where” of climate information (Pasgaard and Strange, 2013; Pasgaard et al., 2015; Skelton et al., 2019), which may influence ownership and commitment to local adaptation efforts (Lahsen, 2016; Blicharska et al., 2017; Skelton et al., 2018). An understanding of local factors that hinder and promote the effective use of climate information in decision-making is deemed critical within the wider literature (e.g., Lemos et al., 2012; Kirchhoff, 2013; Vaughan and Dessai, 2014; Brugger et al., 2016; Nissan et al., 2019; Guido et al., 2020). These considerations fall broadly within the wider context of utilizing climate change risk perceptions as a framing tool to understand and evaluate climate services (Jones et al., 2015; Steynor and Pasquini, 2022), as well as discussions relating to the knowledge and reasoning capacities of individual to form relevant risk perceptions (Kahan et al., 2011). We contrast this context with the concept of *reception*, relating to the manner, way and/or quality in which climate information is received by the user (Hahn et al., 2016), as well as the framework of credibility (relating to scientific adequacy of the information and/or the credentials of the information providers), salience (referring to comprehension and access), and legitimacy (relating to perceived levels of representation, bias and/or participation in the information process) of scientific information (Cash et al., 2003; Guido et al., 2020). Further, we consider the importance of focus on individual thought processes and motivations to act (O'Connor et al., 1999; Wolf and Moser, 2011), as well as the value of understanding heuristics of adaptation (Nalau et al., 2021) using climate information for decision-making. Local voices on the understanding and use of climate information, framed in the theoretical and practical considerations described above, are integral to understanding barriers and encouraging enablers of climate information use within the region.

3. Methods and data

The objectives of the study were to understand the current context of climate information use within the region through a focus on respondents' understanding of the terms DRR, adaptation and resilience (considering the range of temporal scales of action of climate-related decisions), their perspectives on their current use and sources of climate information, as well as their perceptions of barriers and enablers of using climate information. This aim to capture detailed Caribbean-focused perspectives encouraged the use of semi-structured interviews as the main form of data collection. The qualitative nature of the semi-structured interviews allowed for reasonable depth of insight from a wide range of respondents, based on one-on-one discussion (without limitations in candor if done in a focus group setting). Although we had an interview protocol designed to address the three research questions introduced in Section 1, the interview format encouraged latitude to pursue leads and opportunities for follow-up while still retaining options for some standardized, closed-ended questions to give a basis for systematic comparison (Adams, 2015; Krueger and Casey, 2015).

Recognizing that the knowledge needed for adaptation is highly contextual (Ryan and Bustos, 2019), we first sought to understand the scales of action in terms of what respondents were referring to when they said they work on “climate-related decisions” (see Figure 1). Noting the many different definitions and interpretations of the terms *disaster risk reduction*, *adaptation*, and *resilience*, as described within the literature, we solicited their understanding of these concepts as a potential aspect of how it might affect the demand for and use of climate information. Next, we sought respondents’ perspectives of climate information: how it related to different timescales and sources, and their views on its availability and utility (Dookie et al., 2019; CDB, 2020; WMO, 2020). In our initial communication with potential respondents, we included a summary of research interests, and highlighted a definition of climate information as given in the Introduction (Lemos et al., 2012; Singh et al., 2018).

Lastly, we encouraged open-ended discussion about barriers and enablers of climate information use. We asked respondents to share their thoughts on factors which could enable and hinder the use of climate information within the region. Then, to aid comparison, we asked respondents to order a list of eight given factors from most to least influential in terms of their relevance to demand for and use of climate information: financial, technical, capacity/personnel, legislative mandates, loud voices and champions, international drive, local awareness of climate information, donor attention, and “other.” The selection of these factors was based on the literature as outlined in Sections 1 and 2 (particularly Cash et al., 2003; Wolf and Moser, 2011; Lemos et al., 2012) and our understanding of challenges which may typically affect regional decision-making (Pulwarty et al., 2010; ECLAC, 2011; Rhiney, 2015; Mahon et al., 2018, 2019; Dookie et al., 2019). To avoid bias and minimize priming, we did not share this question nor the eight factors in the emailed interview protocol so that respondents were only aware of the identified factors and factor preference process at the interview. During the interview, respondents were asked for their interpretation of each factor to ensure consistency of use. We also requested additional factor suggestions, and asked respondents to order these against the original eight to elicit the relative factor importance.

For sampling, we followed a mainly purposive non-probability design, referring to the iterative “intentional selection of informants based on their ability to elucidate a specific theme, concept, or phenomenon” (Robinson, 2014). While this sampling method does not offer statistical representation of the wider population of interest (of unknown size), it does provide informed insights from a sub-sample that is likely to include a high proportion of what is a small total population. To develop our list of respondents including researchers and decision-makers who could likely be end-users of climate information, we first considered the range of climate-related sectors of interest within the region, including agriculture, climate adaptation, coastal resources and management, disaster risk reduction and management, economics, fisheries, health, hydrology and meteorology, land management, renewable energy, tourism, and water (Robinson and Gilfillan, 2017; Bush, 2018). Noting these sectors, we attended national, regional, and international webinars, reviewed Caribbean-specific academic and gray literature, and utilized personal contacts. To refine the research

questions and minimize bias of the respondent sample, we held preliminary interviews with four resource persons from this list. This allowed for an improved informant awareness and selection as we benefited from suggestions of respondents raised by these contacts. As a note, often, some people were repeated suggestions or persons already on the list we had in mind. Such a process resulted in a diverse list of respondents drawn from various levels/areas of local, regional, and international government agencies, academia, local, regional, and international development agencies, private sector interests, chambers of commerce, and civil society. An effort was made to secure both a gender balance, and due to the nature of institutions working on related topics within the region, we also aimed to prioritize local/regional representation.

Using this process, we reached out to 60 persons *via* email as well as networking platforms such as LinkedIn. We received 32 responses of interest to participate, which we followed up by sharing more details on the research and the interview protocol, as well as information on consent and the modality of the interview. In the end, 26 persons completed our interview process. As agreed by consent form, interviewees have been kept anonymous and a detailed summary of respondents is not offered due to the small nature of the participant base, but Table 1 summarizes a selection of characteristics of the 26 respondents while Table 2 offers some individual insights. As shown, of the 26 respondents, 20 were persons within a regional background, while 6 were of international origin working on Caribbean-related topics (one of them working within the region for at least 10 years). Despite our efforts to ensure a gender balance, 10 of those interviewed presented as a woman. There is a variety in the locality of focus, with 5 persons offering that they worked mainly within national interests, 12 worked within a regional and/or multiple country interests, and 9 working across both national and regional interests. Through the interviews, we discovered that persons worked in, had experience with, and/or were from countries including Antigua and Barbuda, The Bahamas, Barbados, Dominica, Grenada, Jamaica, St. Lucia, St. Vincent and the Grenadines, and Trinidad and Tobago. There was also a variety of sectoral backgrounds, including physical sciences such as meteorology, climate and agriculture, and social sciences such as related to tourism, development studies and economics; they operated in roles relating to research, such as at local universities, as well as policy and practice, such as within NMHSs, and national, regional, and international agencies. In the summary information on respondents, we did not specifically identify the years of capacity at their current place of work since we felt that this did not reflect the culmination of efforts in other capacities. Several respondents hold simultaneous positions, and many were able to offer perspectives based on both current and previous experience within the region. As well, we did not identify their country of origin since many have worked/continue to work in multiple countries, which collectively influence their experiences and perceptions. While some respondents were able to give perspectives both from a regional and national viewpoint based on their background, due to the small sample size this research does not attempt to isolate individual country trends. As noted, we do not purport to incorporate probability sampling in our approach and the results should not be considered representative

TABLE 1 Summary of respondents.

Gender		Background		Regular CI use		Country focus	
Female	10	Caribbean	20	Yes	12	National	5
Male	16	International	6	No	14	Regional/multiple countries	12
						National & Regional	9

TABLE 2 Characteristics of respondents.

ID	Country focus	Sector focus
1	Regional/multiple countries	Climate
2	Regional/multiple countries	DRR/DRM
3	National & Regional	Climate & DRR/DRM
4	Regional/multiple countries	Climate & DRR/DRM
5	National	Climate
6	National & Regional	Fisheries
7	National & Regional	Climate/coastal
8	National & Regional	Climate/land management
9	National & Regional	EcoNomics/Climate/DRR
10	Regional/multiple countries	DRR/DRM
11	National & Regional	Sustainable Development
12	Regional/multiple countries	EcoNomics
13	National	Varied/Wide focus
14	Regional/multiple countries	Agriculture
15	Regional/multiple countries	Climate/Agriculture
16	National	Climate
17	Regional/multiple countries	Varied/Wide focus
18	Regional/multiple countries	Climate & DRR/DRM
19	Regional/multiple countries	Climate & DRR/DRM
20	Regional/multiple countries	Sustainable Development
21	National	Climate
22	National & Regional	DRR/DRM
23	National & Regional	Climate
24	National & Regional	Climate & DRR/DRM
25	National	Climate/Agriculture
26	Regional/multiple countries	Tourism

of national or regional estimates (Ryan and Bustos, 2019), or the sectors represented by the respondents.

Due to the ongoing coronavirus pandemic, we used the Zoom web-based conferencing platform which gave acceptable replicability of in-person interviews, convenience, as well as ease of use and cost-effectiveness (Archibald et al., 2019), in addition to being carbon-efficient. The modal average interview length was 1 hour.

The interviews were transcribed *verbatim* at the time of recording and corroborated against the recorded audio for

confirmation. Transcripts were supplemented with further email communication and sharing of relevant documents; respondents were also emailed their factors of preferences for confirmation and were encouraged to add context. Interview transcripts were then coded manually, with open-ended questions coded according to inductive reasoning through a comparison of recurring points within the interview responses and compilation of emerging themes. This use of thematic analysis was important to us due to the method's relevance and power in "seeking to understand a set of experiences,

thoughts, or behaviors across a data set,” and its design to focus on or shared meanings rather than “unique meanings or experiences from a single person or data item” (Kiger and Varpio, 2020). Thematic interpretation was considered within a general social constructivist research paradigm, and a selection of representative narratives was extracted to highlight the range within each theme.

Since there was one closed-ended question regarding factor preferences, this was coded deductively since we had already pre-defined the factors. However, since there was much debate by respondents on how to decide on the factors—often, respondents could not select one factor over another and had “tied” factors—we flexibly decided to integrate this process within our research. As such, a mental mapping of the process was designed to help visualize how decision-makers approach and prioritize the use of climate information within the region. We compiled this mapping using NodeXL, a free network analysis and visualization software package.¹

As this research is meant to offer a starting point on local perceptions of climate information use, we feel confident in the quality and suitability of the respondents who accepted our invite to participate. While maximal efforts were made to conduct further interviews, we feel reassured by the recurring themes and the petering trend of new ideas with each additional response inferring some level of saturation (Saunders et al., 2018). As caveats, we again note that our sampling method meant that we were able to only draw perspectives from a diverse sub-sample and as such we are not able to make generalized conclusions about the Caribbean-wide population of interest nor attain quantitative representation of national nor sectoral interests. As well, we were only focused on the perspectives of a wide range of persons within our sub-sample and have not focused on the inter-comparability of individuals’ efforts or backgrounds, the scope of climate information use nor the extent of climate-related decisions taken by these individuals. Lastly, while all efforts were made to gain some insight from persons in many climate-related sectors, we are aware that this was not entirely possible both due to the intersectional nature of climate within different spheres of Caribbean action (there may be areas which we were not aware of), and that there were persons who either did not respond to our contact or could not participate in our research.

4. Findings

4.1. Understanding the terms DRR, adaptation and resilience

Respondents were asked to discuss their perspectives of the terms DRR, adaptation and resilience, noting the range of climate-related decision-making across different timescales. Interview responses show some difference in attention to the various terms, due to core responsibilities, donor interest and/or recent events, and some interchangeability in their use.

One respondent mentioned that there were no formal definitions of these concepts used by their organization and they were “guided by those used by organizations such as IPCC” (ID05). For others there were a range of definitions and attribution of the concepts to different ministries, departments, agencies, institutions, or sectors with relevant mandates (IDs 1, 3–4, 7, 15–16, 18–19, 21–22, 24). It was stressed that effort on these varying decision timescales may also be dependent on or “divided in terms of which agency leads on that agenda ... [and] the importance of the agenda depends on other political factors” (ID03), and it could likely be “project focused” (ID03). Specifically, there was a perspective that donor agendas and related financing may be available only on certain topics (IDs 3, 13, 17–19, 21), which may conflict with local priorities for current action. As well, it was highlighted that while climate change is a larger concern beyond a focus on extreme weather events—“it’s not [only] hurricanes” (ID11)—at the same time, there was an increased awareness and channeling of climate-related funding, particularly due to recent extreme events. Although the impacts of disastrous storms within the region were felt to signal attention and the need for assistance to focus on resilience and longer-term adjustments in policy, some respondents still questioned whether there was sufficient attention to shorter-term measures relating to DRR and preparedness.

In terms of the utility and focus of concepts, resilience was noted as perhaps a “better term to encapsulate everything” (ID04), especially considering other development efforts on the Sustainable Development Goals and the blue economy. Resilience was perceived as “more flexible” (ID04). However, there was a range of interpretations of the concept, and concern was expressed about politicization, as resilience seems to be a “word and concept championed by [certain leaders] ... after [2017’s Hurricane] Maria” (ID03, also brought up by IDs 12, 17–19). Further, it was suggested that resilience could be just a “label” (ID02), especially since the Caribbean was already considering longer-term changes (e.g., certain building requirements and changing infrastructure accordingly). One respondent was concerned that “we will never achieve resilience since the goal post is always shifting” (ID01). One manifestation of a DRR vs. adaptation focus was related to responsibility of effort, as “historically countries have taken the responsibility of DRR” while responsibility for adaptation rested with the international community and developed countries (ID24).

Interchangeability in use of the terms DRR, resilience and adaptation depended on the person asked, the sector, and the country (IDs 3–5, 7, 13, 15, 17, 22). Respondents mentioned that while more technical persons may be aware of differences and timescales within these discussions, there was a sentiment that senior officials and those in ministerial capacity may not. This could be due to the general “public understanding of science and ... climate change” (ID11, also raised by IDs 13, 15), and whether there is an appreciation of differences between climate variability vs. climate change. Finally, concern was noted about attribution; “tendency to attribute to climate things [that] are not climate but our own [actions]” (ID11). In summary, our results show diversity, e.g., one respondent felt that perceptions are “completely different depending on country” (ID03) and as such these perspectives are not meant to generalize the response of any one country or the wider region.

¹ NodeXL software, <https://www.smrfoundation.org/nodexl>.

Considering the backgrounds of respondents based on Table 1, persons with an international background seemed more inclined to mention issues relating to donor agendas rather than those with a local background. As well, international respondents working within the Caribbean space highlighted the politicization of the term resilience more than local respondents.

4.2. Understanding the use, nature, and source of climate information

Of the 26 respondents, 12 persons suggested that they use climate information either directly or in customary practice within their work. Many persons mentioned not being specifically trained on using climate information, but that they might seek it for a particular decision or discussion. Others noted that climate information was embedded within organizational functions, e.g., their role warranted “*automatic inclusion of climate information ... [since] funding agencies need to see evidence*” (ID01). Climate information was also highlighted as a required element for their work since the “*focus is on making communities more robust*” (ID03). Further, it was mentioned that while some might be aware of the utility of climate information, its actual use in decisions may not be up to the choice of the respondent.

In defining climate information, responses included outlines of the several types of data necessary for many climate-related decisions within the region on different timescales, however, some were hesitant in defining it or being explicit about it. One respondent described climate information as “*everything that empowers persons to build their own resilience. Science, climate series, instrumentation to empower agencies [and] industries, which helps them build their own resilience, and build their own knowledge base*” (ID01), noting that despite any definition there are various levels of comprehension, and that “*information is only as good as understood by receiver*” (ID01). This sentiment of climate information awareness and utility was echoed in other responses, as it was considered imperative that information should reach the user in a form that they could understand, especially when considering the local public and private sector understanding of science (IDs 11, 13, 15). Moreover, the term “information” often implied that raw data needed to be formatted or translated in some way (IDs 1–2, 18–21, 23).

When asked about where they sourced climate information, respondents mentioned efforts by their respective NMHSs, the Caribbean Institute for Meteorology and Hydrology, the 5Cs, as well as the Climate Studies Group of the University of the West Indies in Mona, Jamaica. The international community was “*usually seen as an authority*” (ID02). Also, while respondents who routinely use various aspects of climate information seemed confident about their sourcing and the types of data available, one person used search engines to find information, even using proxies of data for other countries for local estimates. Respondents who were more aware of climate information, noted the differences between timescales and their relevance for decision-making. For instance, contextual “*seasonal and short-term information ... [was required] for making decisions about preparedness*” (ID03). Effort to obtain finer spatial and temporal resolution data was

noted, for both shorter-term and longer-term global climate model projections, as current data were often too coarse for specific locations or even entire islands (ID05). Respondents highlighted that user-related challenges of accessing and applying this information (IDs 2–3, 5, 12, 17), and compatibility with socio-economic and other interdisciplinary data (IDs 12, 20, 22), sometimes outweighed the need for specificity. Data management concerns were highlighted by seven persons.

Based on the summary of respondents in Table 1, it seems that there was a general interest and necessity of understanding and using climate information, even by respondents who did not suggest that they used it directly or daily within their work. Although those with current use offered more context of the sources and nature of climate information, there was a common element of challenges of using available climate information.

4.3. Factors influencing climate information use in the Caribbean

4.3.1. Barriers

Regardless of the extent to which they currently use climate information, respondents were asked to identify barriers, i.e., factors which may *likely hinder* the ability of local agencies to use climate information. Only two participants did not offer responses to this question, and respondents were able to suggest more than one factor, if necessary. There were four main categories of barrier factors emerging from a total of 63 perspectives by respondents: application and utility of climate information, awareness and access of climate information, political and policy issues, and resource constraints. A description of these categories and a selection of narratives for each of the themes is given in Table 3.

Three of the themes, application/usability, awareness, and political/policy concerns, received almost the same number of mentions by respondents. Political or policy-related concerns were the most cited (with 18 mentions), with challenges including a changing government alignment (due to shifts in political/ministerial regime), an “*inability to involve politicians*,” and limited political mandate to encourage climate information (e.g., “*minimal mandate*” and “*doing as in the past*”). Other barriers that were mentioned include a general “*siloed approach*” to focusing on priorities within the region (e.g., “*gap between knowledge and implementation*,” “*hard to connect impact and climate information*,” communication problems, and competition with other priorities (e.g., “*climate not seen as economic*,” “[perception of more pressing] *development concerns*”).

Application/usability-related barriers were mentioned 17 times by respondents. This broadly included limitations related to the format in which the data is presented for analysis or interpretation (e.g., “*how do you use that data for your purposes*,” “[need] *form that is applicable*,” “*format not understandable*”), as well as the need for better interpreting of the data (based on respondent references including “*translating this raw information*” and “[challenge to] *interpret the messages*”). Specific factors relating to the challenges of “*visualization*,” “*real-time availability*” and “*certainty*” of data were also mentioned, and through discussion the appropriateness

TABLE 3 Selection of narratives on the barriers of climate information use.

Summary factor	Description	Selection of narratives
Challenges of climate information usability and applicability	Respondents mentioned challenges relating to the limited usability and applicability of available climate information due to presentation and available formats, as well as the need for translating or interpreting the data	<ul style="list-style-type: none"> – “It’s one thing that you’re in a sector that rainfall patterns can change, and you see a graph, but how do you use that data for your purposes? Having the capacity to not only receive [climate information] but move beyond this” (ID16) – “Presented in technical and scientific language ... is how it applies to me easily identifiable? [Need] capacity to understand information” (ID21) – “[Need for] training the trainers... [Need] to make people more skilled to understand and interpret the messages providing the key information” (ID23) – “Climate information needs to be presented in ways that relate to their imperatives” (ID6) – “Need something easy to refer to ... [problem is that climate information is] collected for different reasons, difficult for comparisons” (ID17) – “[Climate information is] specialized information not readily consumed by everyone ... Not everyone in research and ministries can use... needs expertise [for] translating this raw information” (ID9) – “Still some [areas] where research has not yet been done. The less information that comes from your regions the less contributions that will be included in international reports. The Caribbean is under-represented in papers that IPCC reviews” (ID13)
Challenges of climate information awareness, availability, and access	Respondents mentioned challenges relating to not being aware of what climate information is available, or not sure of where to look, or not having access to information. Problems of data-sharing and compatibility across differentiated data platforms, the challenge of understanding uncertainty, as well as the need for dissemination and outreach were also mentioned	<ul style="list-style-type: none"> – “Not knowing where to go for information; challenge of hunting down information ... Poor culture of sharing information across agencies, ministries. If they know there’s information readily available then will seek out. A lot of work being done to collect interesting information, but not packaged to be easily shared to end users, and little investment of wanting to share” (ID4) – “Sometimes you have too much information, not sure what to believe ... we don’t dedicate people to dissemination and outreach” (ID24) – “Lots of information out there; what information is being used, is it usable? ... Challenges of data gaps and data access” (ID22) – “Challenges of data sharing ... in Europe there is a public value of databases” (ID19) – “Misinterpretation of uncertainty and understanding what it means within context” (ID15)
Challenges related to political and policy issues	Respondents mentioned challenges relating to the changing alignment of the relevant organizations and/or government in terms of political cycles, challenges related to the framing of climate information/climate change within the context of other societal issues, as well as the siloed nature of responding to climate change	<ul style="list-style-type: none"> – “Changing head of government and organization not always good. Changing alignment” (ID5) – “If ... there is a way to do things differently from in the past” (ID7) – “How is climate [change/] information different from other social issues, poverty and development? Climate change is crosscutting, but it can’t be distracted by something difficult to understand” (ID7) – “Siloed policymakers ... Don’t bring them in at the end, should be there at the start” (ID20) – “Until the environment becomes an important issue, then people in government will pay less attention to it... Climate doesn’t move until it becomes an economic issue” (ID11) – “Politicians are afraid of the impact of science on their bottom line, likely the next election” (ID6)
Need for additional resources	Respondents mentioned challenges related to insufficient resources and capacity to use/support climate information (i.e., human capacity, financial, and technical/technological)	<ul style="list-style-type: none"> – “[Need] financial resources to support staff. Downloading data need technology and hard resources” (ID7) – “Capacity constraints, planning. Not using information and data in planning. Not technical, but human capacity. People not having time to have proper planning” (ID3) – “[Challenges of] cost, maintenance, lack of human capacity ... how to do the analysis and have that training” (ID25) – “Capacity constraints [related to] translating raw information” (ID9)

This table offers selection of narratives relating to the posed question, “what are the barriers, i.e., factors which may likely hinder the ability of local agencies to use climate information?” 24 of 26 interviewees offered a response. Respondents were able to suggest more than one factor, if necessary.

or relevance of the data for the small islands of the region (e.g., “limited output from region”) was also mentioned.

A low level of awareness of climate information in the region was also deemed a significant barrier, with 17 mentions by respondents. This included speculation that local agency officials may not know that data exist (e.g., “[limited] awareness of what is available,” and “lack of awareness”), or, if they

did, they would not know where to access it (e.g., “where to go for climate information,” “[need readily] identifiable data,” “limited dissemination and outreach”). Respondents stressed access problems, and challenges with data management and sharing, nationally and at the regional level, were also stated as barriers. These concerns related to institutional reluctance to share data (e.g., “challenge of sharing data,” “difficulty with national

data”), possible “*institutional jealousy*,” and lack of legislation to encourage sharing and ease of management. Connecting climate information with other data was also found to be difficult due to different platforms and associated challenges of multi-disciplinary datasets (e.g., “*different info platforms*,” and “*limited availability of other data*”).

Resource constraints rounded out the barriers with 11 mentions, mostly referring to human resource capacity concerns (respondent references including “*human capacity constraints*,” “*capacity to utilize*,” “*training needs*,” and “*education system*”). Financial and technical constraints (e.g., “*data and analysis skills*” and “*adaptation to new technologies*”) were also specifically mentioned.

While respondents who did not directly use climate information offered contexts of challenges relating to awareness and application, as expected, similar issues were also raised by those more familiar with climate information. There did not seem to be a discernible difference of issues raised by respondents with a local compared to international background—both groups mentioned shared challenges, including those relating to human resource capacity, changing political alignment, and a data sharing problem.

4.3.2. Enablers

Respondents were also asked to identify enablers, i.e., factors which they believed would *likely encourage* the ability of local agencies to use climate information for climate-related decisions; only one person did not offer a directed response. Using their own words, Table 4 summarizes the suggestions from the 25 respondents who answered this question. Based on recurring themes, these factors have been categorized into four areas: contextual relevance, application, translation and training, basic awareness, and access, and other. As with the barriers, respondents were allowed to suggest more than one factor, if necessary.

Most of the factors suggested by respondents focused on the need for improved local and sectoral contextual relevance (30 suggestions). Narratives included the need for data that is of relevance to a small island setting (e.g., “*need to work within small island needs*,” and “[make] *relevant at local scale*”). As well, a better understanding of the direct utility, as well as economic bottom line/costs and benefits, of climate information was also highlighted (with respondent comments such as “*need quantifiable impact*,” “*connecting data and economy*,” “*connecting to socio-economic data and impacts*,” “*understanding associated risk*,” “*direct utility*,” “*illustrating value*,” “*impacting pockets*,” “*impacts cost money*,” and “[need to] *relate to costs*”). Respondents mentioned having climate information as well as key partners and stakeholders associated with such information engaged and included at early or “*integral*” stages of decision-making processes. In addition, “*making climate information a requirement*” in certain decisions and the project process could be helpful.

Respondents also mentioned the influencing nature of improved climate information application, translation, and training, with 12 suggestions in this category. Importantly, perspectives included the need for improved awareness of how to apply the available climate information (e.g., “*knowing how to*

apply”), as well as the need for improvements in the formatting and presentation of information in a way better understood by many, including policymakers (e.g., “*translating scientific knowledge*,” “*need simplified version*”).

Several enabling factors were awareness-related (10 suggestions) including improved “*awareness of the existence*” of relevant types of data, “*knowing where to go*” and having “*official/verified sources*,” “*access to timely data*,” and as well the need for “*dissemination and outreach*,” perhaps through social media or civil society.

Enablers related to recent events were mentioned by four persons—several respondents mentioned that a renewed attention to climate information occurs just after extreme weather events (and a lack of interest otherwise). Specific motivations relating to funding, including the option to “*incentivise resilience building*,” were also suggested as enabling factors.

Considering the background of respondents, while persons from both local as well as international backgrounds felt that a better understanding of the utility of climate information could assist local and sectoral contexts for improved awareness of use, those with local backgrounds more often had the suggestion to connect climate information to the economic bottom line. Local respondents also highlighted the role of recent events in bringing attention to the use of climate information, and discussed the role of social media, youth, and community organizations, as well as improving the stakeholder engagement process.

4.3.3. Factor preferences

To better understand the relative importance of factors, respondents were asked, “*what are the factors that would drive the demand or use of climate information for various climate-related decisions?*” As per Section 3, we offered eight main factors—financial, technical, capacity/personnel, legislative mandates, loud voices and champions, international drive, local awareness of climate information, donor attention, as well as “*other*”—to be ordered from most influential (i.e., first preference) to least influential/least preferred. While all participants answered this question and used at least one of the factors on the list, some found it difficult to choose just one factor over another in preference. Some respondents judged factors at the same level, and/or offered reasons for the difficulty in placing certain factors higher or lower than others.

Financial factors were included by almost all participants on their list (24 persons out of the 26 interviewed). It was first preferred by nine respondents (IDs 2, 4, 11, 12, 13, 15, 19, 22, 24), and second preferred by five respondents (IDs 1, 9, 17, 18, 26). Many respondents understood “*finance*” as “*national sources*” noting that having a local source of funding, especially outside/after an external funding cycle, could in their view be an important influencing factor for the sustained demand and use of climate information. Donor attention also was a very highly preferred factor, with eight persons listing it as a first preferred option (IDs 8, 9, 11, 12, 17, 20, 22, 24). Two respondents listed “*donor attention*,” related to the influence of current donors on the issue of climate information,

TABLE 4 Selection of narratives on the enablers of climate information use.

Summary factor	Description	Selection of narratives
Improved contextual importance	Respondents described the need to have better context of the climate information available, in terms of localized and sectoral importance	<ul style="list-style-type: none"> – “Talking or working between stakeholders and provider to build trust and language, and filter out what is not usable to make sector relevant” (ID10) – “[If you can show] how it impacts their pockets and safeguarding investments” (ID13) – “Not enough localized information ... [need to be] relevant at local scale and used to connect to adaptation response” (ID21) – “Proof of the pudding. Need to show that the utilization of this information can impact institutional bottom line. Need to convince minister of X, or funding agency to use it. Being able to show direct utility” (ID6) – “Policy platforms need to have a real space for scientists to get climate information on the agenda... [use of] ministerial councils” (ID7) – “Scenario planning. When they are setting their budgets, thinking of which programmes they want to continue with, to show them an approach to planning that will highlight scenarios. And show impacts... people have a lot of experience and tacit knowledge of how to do things, [but need to] make it more tangible for them” (ID3) – “Requirement of climate information is a major factor” (ID1)
Improved application, translation, and training	Respondents described the benefit of knowing how to apply climate information, as well as its presentation in less scientific and more usable formats. Training to use this information was also important	<ul style="list-style-type: none"> – “Knowing how to apply [climate information], [need] level of how to use this (ID17) – “Need for scientists to show information presentable to non-scientists ... how do we bring [it] across in a way to be accepted?” (ID6) – “Translating scientific knowledge [into something] that politicians can understand... fancy technical words difficult for policymakers” (ID18) – “Format and how the message is formulated. Climate providers and intermediaries need to make more efforts to adapt the message and the format to the sectors that they are trained to reach” (ID24) – “Climate and its impacts still an optional study area, when it should be compulsory.” (ID25)
Improved basic knowledge and access	Respondents mentioned the need to at least be aware/know that the data existed, and where to look for the data. As well, having ready access to climate information was important	<ul style="list-style-type: none"> – “Knowing that the data exists” (ID16) – “If you want to plan and make informed decisions, need data to help them do that” (ID4) – “Access to... information on a regular and timely basis” (ID2) – “Making extremely easy to access data, something that they can do” (ID3) – “Social media and digital media can assist, search for something and you can find”; “Youth and community organizations [offer] wider acceptance of climate information at societal level [allowing that a] basic knowledge level of climate change is met” (ID24) – “So much information, some are very different sometimes, information sharing is a challenge. Question of how we as a country do data generation, collation and access is a key pathway to more effective use of climate information and its application” (ID22) – Data policy ... look for this to see how it hinders accessibility and sharing (ID16) – “Awareness at highest political agency ... [need] massive increase in public awareness, needs to be a demand from a public” (ID10)
Other	Additional enablers included the motivation to use climate information due to the recency (there may be upticks in use post-recent events), and funding would be a motivating factor for use	<ul style="list-style-type: none"> – “We have a tendency to be driven by events” (ID11) – “Stakeholders have indicated a lack of interest in climate information except weather reports during the Atlantic Hurricane Season” (ID26) – “Build financial structures to build this up without a need for external funds” (ID10)

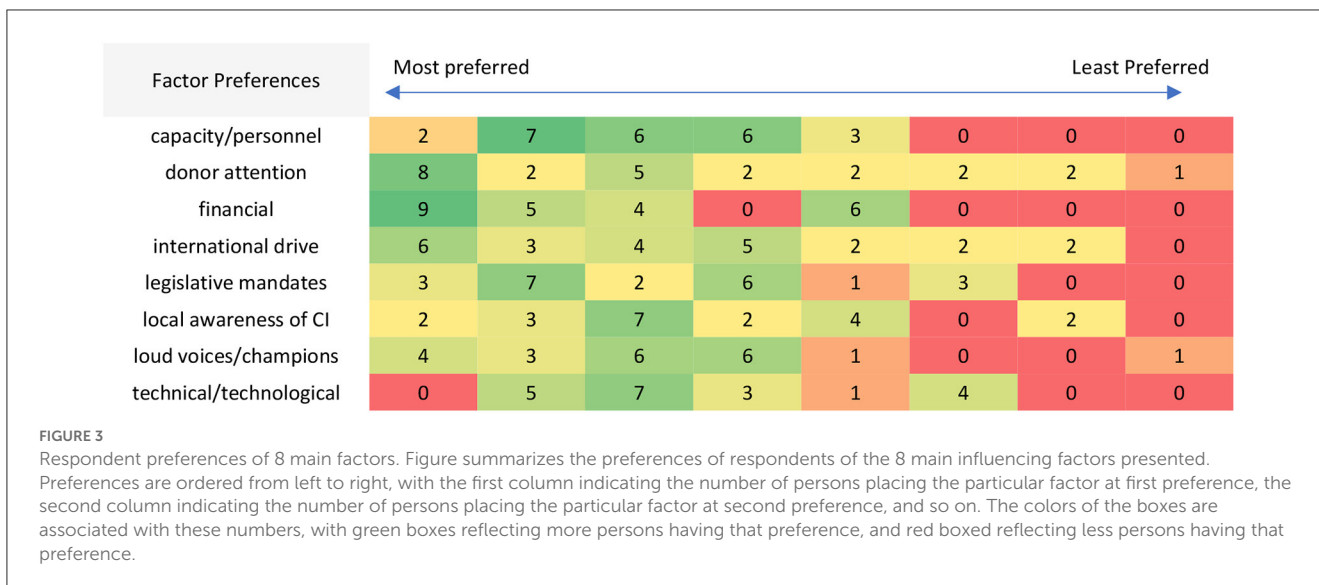
This table offers selection of narratives relating to the posed question, “what are the enablers, i.e., factors which may likely enable the ability of local agencies to use climate information?” 25 of 26 interviewees offered a response. Respondents were able to suggest more than one factor, if necessary.

as second preferred (IDs 6, 26), while five listed the factor as third preferred (IDs 2, 4, 5, 16, 21). Related to these, the factor “international drive” which referred to the global attention to climate change and climate information, was listed as first preferred by six respondents (IDs 1, 3, 5, 8, 21, 22), and second preferred by three persons (IDs 11, 24, 25). Respondents mentioned that a wider international focus on applications which might require the use of climate information could influence national or regional use of climate information.

Champions of climate information were also seen as an influential factor: four persons mentioned it as their first preference factor (IDs 1, 6, 14, 25), and three persons thought it to be second

preferred (IDs 7, 8, 23). This factor was described as the influencing nature of a wide range of activism at various levels by local, regional, and international persons (politicians, scientists, celebrities, radio presenters) on encouraging awareness and thereby use.

While the factor “legislative mandates” was first preferred by three persons (IDs 7, 23, 26), seven persons considered it as a second preferred factor on their list of influential factors driving the demand or use of climate information within the region (IDs 3, 5, 12, 13, 15, 19, 21). This factor related to having mandates or provisions in place to encourage the use of climate information in various settings. In this sense, there was specific mention of data management provisions which would not only



encourage agencies to collect and use climate information, but also share data with other agencies/ministries, either locally, nationally, or regionally.

Respondents confirmed that the factor “capacity/personnel” or having “bodies in the office” to work on applications utilizing climate information, as well as having the skills/training of the workforce to understand its potential and to use it, was a concern. The factor was first preferred by only two persons (IDs 16, 18) but there were seven persons who thought it was a second preferred factor on their list (IDs 2, 4, 10, 14, 17, 20, 24).

Though the factors “local awareness of climate information” as well as “technical/technological” resources were not considered to be the most preferred factors influencing demand and use of climate information, there were seven persons considering each of the factors as third preferred.

While these preferences serve to showcase the experiences of local respondents, given the high proportion of respondents with such backgrounds, it is of interest to consider the varying preferences of the 6 international respondents that we interviewed: donor attention, capacity/personnel, finance, international drive, local awareness of climate information, and legislative mandates. We have tried to summarize these results within Figure 3.

4.3.3.1. Additional factors

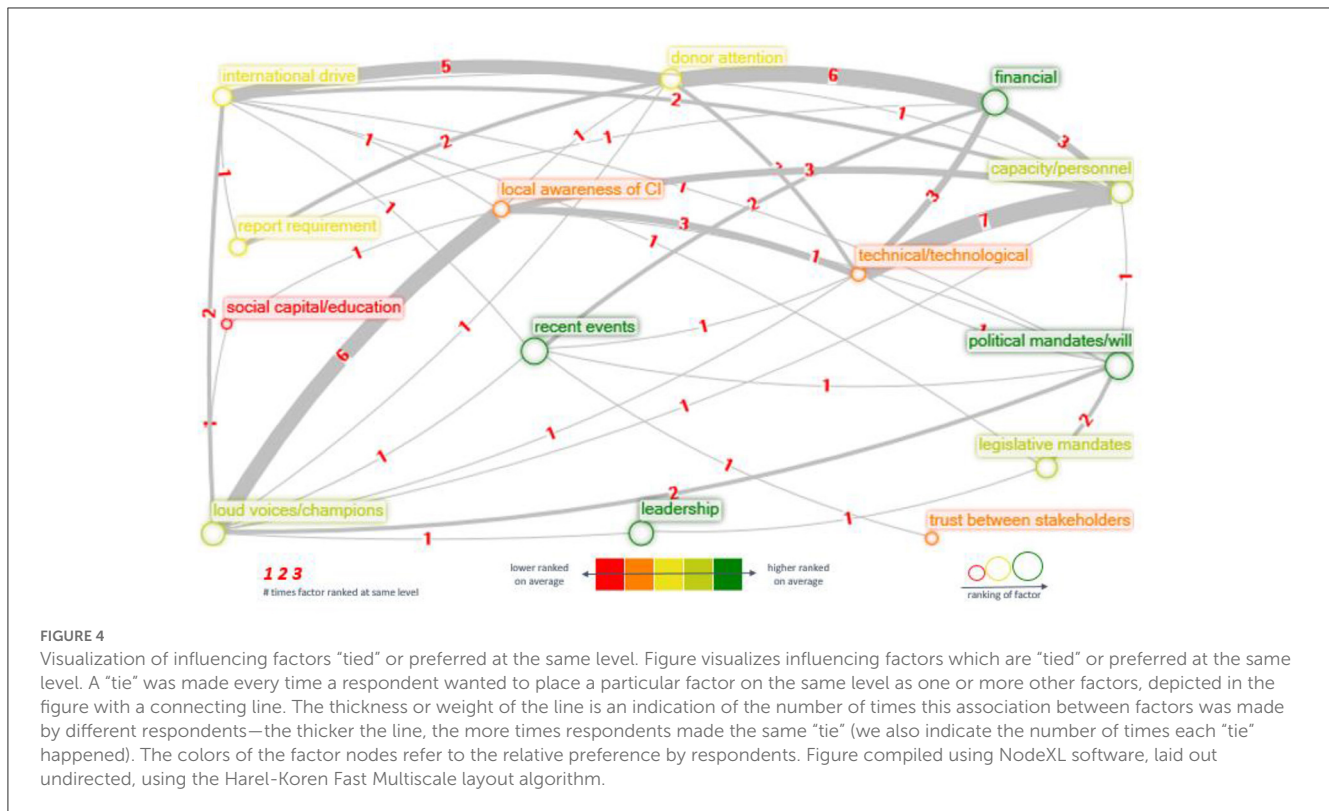
While many persons confirmed that the eight factors list above were among the strongest possible sources of influence for using climate information, some respondents also suggested that there were other notable factors to consider apart from these eight. In total, seven additional factors were mentioned: political mandates/will, recent events/local experience, reporting requirements, leadership, trust between stakeholders, social capital/education, and local canvassing. Three of these additional factors were highly preferred, relative to the other factors on this list—recent events/local experience, political mandates/will, and report requirement.

During the discussions, six respondents (IDs 1, 5, 8, 15, 17, 26) felt the urgency of recent events highly influenced desire to

utilize climate information in local decision-making efforts. This is because particularly devastating events which occurred locally, or even regionally, encourage the national public and decision-makers to demand attention to climate-related decisions. Respondents (IDs 1, 4, 6, 7, 10) suggested that political will was a strong motivating factor, based on the resolve of politicians to ensure that the effective use of climate information was seen as a high priority of effort. Having such a force in place could eclipse other factors generally seen as positive such as funding or international drive. As well, if there was an obligatory requirement to use climate information within daily work and reporting structures, this would surely have an advantage of climate information being more and better used within the region (IDs 18, 22). They noted that its current use is on a voluntary basis, and given limited human and technical resource capacities, this may fall low on the priority list of activities and simply not happen.

4.3.4. Visualizing “tied” factors

As mentioned, some respondents found it challenging to isolate factors in terms of preferences. They often wanted to place two or more factors at the same level since they were unsure how/if they could place one factor higher or lower than another, or that they felt that certain factors were connected. As such, we allowed a “tie” of factors at the same level. To visualize these connections, which could offer some insight into the perceived linkages between factors, we used NodeXL software to compile “tied” factors (laid out undirected, using the Harel-Koren Fast Multiscale layout algorithm designed for aesthetically pleasing and simplistically optimal mappings), as shown in Figure 4. A “tie” was made every time a respondent wanted to place a particular factor on the same level as one or more other factors, depicted in the figure with a connecting line. As shown in the figure, the thickness or weight of the line is an indication of the number of times this association between factors was made by different respondents—the thicker the line, the more times respondents made the same “tie”



(we also indicate the number of times each “tie” happened). The colors of the factor nodes refer to the relative preference by respondents.

The mapping highlights “tied” factors only based on respondents’ perspectives. Factors such as *capacity/personnel* and *technical/technological* were the most “tied,” with seven persons preferring them the same (i.e., they found it difficult to disconnect the importance of human resources and technical resources). Likewise, having active *loud voices/champions* were “tied” to *local awareness of climate information* by six persons. The connection of *donor attention* with *financial resources* is not surprising but useful to point out in this mapping. While financial resources are generally viewed as overall important influences, as identified in the previous section, some respondents felt that the role of donors was equally important suggesting that for developing countries such as Caribbean small islands donors are inextricably linked to funding options and play a vital role in influencing climate information use.

Interestingly, all first preference “ties” were made by respondents from within the region; three of the six respondents within an international background made the specific “tie” between the factors *capacity/personnel* and *technical/technological*. Although the connections between factors are not directional or causal, this visualization highlights the complex relationships between factors that assist the use of climate information and insight into the internal heuristics respondents use to organize this complexity. It reminds us that encouraging the use of climate information use requires attention to a suite of enabling factors and conditions, rather than emphasis on any one factor. For

many respondents it is not simply a question of “more funding is needed” or even that there is a knowledge deficit, but a more comprehensive understanding of the intricacies of local challenges that determine climate information demand and use in the region.

5. Discussion

In this paper, we have discussed elements of the current context of climate information use in the Caribbean through an analysis of responses by 26 Caribbean-focused sectoral experts to the aforementioned research questions. Overall, there is interest in the role of climate information to boost the region’s arsenal of knowledge to prepare for and respond to weather and climate-related impacts. Yet, while even persons with limited direct use are aware of climate information, all persons, regardless of context of use, sectoral or national background, identify a range of barriers of climate information use.

Based on Section 4.1, a first key finding of this study is that respondents’ perspectives on the concepts of DRR, adaptation and resilience show various understandings of definitions and agreement of scope, irrespective of respondent background. While we asked respondents to offer their understanding of each of the concepts, few gave definitions and rather opted to discuss wider contexts and the possibility of some level of interchangeability. This understanding is akin to the findings of [Saxena et al. \(2017\)](#) which analyzed the responses of 35 climate change donors and project implementers in the Caribbean and found varying interpretations of “resilience.” While our study differs from [Saxena et al. \(2017\)](#) due to our wider respondent base, the outcome

implication is similar in that different values and interpretations could complicate “communication and action across various actors working at different scales and in different local contexts” (Saxena et al., 2017, 157). Increased understanding and harmonization of the definitions and their use could facilitate improved collective communication of gaps and needs within the region and strengthen programmatic focus. This could include better alignment of project aims and outcomes—how they address DRR, adaptation and/or resilience—and potentially affect their eligibility for climate finance.

Considering the respondents’ narratives in Section 4.2, there is broad awareness of climate information and the customary sources of information within the region. These findings confirm that efforts by NMHSs, the CIMH, the 5Cs, as well as the Climate Studies Group (as highlighted within Figure 2, and in Section 2), are likely reaching the intended end-users. However, compared to the study by Mahon et al. (2021) which only interviewed persons from the tourism sector, our cohort with a wider thematic/sectoral base did not explicitly identify as many specific information sources. It is uncertain whether this contrast of information sources could be due to the sample or the interview process, but both studies confirm similar barriers to climate information use including challenges relating to awareness, application/usability of information, and a limited capacity to utilize information (Mahon et al., 2021). As such, despite the long history of projects/programs which have supported provision of climate information for its use in the region (see Figures 1, 2), there is yet a presence of stubborn barriers and a failure to look beyond narrow assumptions about what drives information use (Sections 1, 2).

A further key finding and subsequent recommendation is the need for contextualized climate information, i.e., considering both island geography and local climate-related socio-economic influences (e.g., Skelton et al., 2018). This relates to the island setting, as well as the packaging and dissemination of information in ways that are tailored to, and understood, accessed, and utilized by, diverse groups of decision-makers, across a range of timescales. These insights reflect seminal work by Cash et al. (2003) (see Section 2) on the importance of credibility, salience, and legitimacy for effective use of scientific information (Cash et al., 2003, p. 8086). Firstly, interviewees described the lost opportunity of not connecting the direct utility of climate information with local and regional priorities (institutional bottom lines), highlighting a lack of salience. However, a challenge to achieving usability is the limited availability of localized information (with data management identified as a barrier), and the current elevated levels of uncertainty. This stirs elements of a lack of credibility, relating to scientific adequacy of the information and/or the credentials of the information providers. As one official put it, there was a “principle of optimal ignorance ... [as it is] better to be roughly right, than precisely wrong.” Further, as expressed by one respondent, “information is only as good as understood by receiver.” This signals the need to better understand challenges relating to the interaction between awareness or observation of climate information, and its reception by the user community. As well, this insight underscores the need for improved translation of climate information into more usable formats (Marx et al., 2007; Lemos et al., 2012) and the specific need for encouraging a space for climate science translators (Enekel and Kruczkiewicz, 2022) to assist with making climate

science findings more accessible or useful for the community of practitioners.

Another key finding relates to the focus on donor attention and international drive, raising questions of legitimacy (i.e., perceived levels of representation, bias and/or participation in the information process). Although the term legitimacy was not specifically mentioned within the discussions and does not explicitly appear as a barrier or an enabler, the factors “donor attention” and “international drive” were very highly preferred (Section 4.3.3.). As well, the mapping of “tied” factors (Figure 4) shows that respondents considered them highly linked particularly with financial resources. Although respondents noted the value of international financial support and expertise, this linkage (manifest as influence) sometimes meant that project focus may not always align with country focus. For example, shifts in the use of the different concepts of DRR, resilience and adaptation could be likely driven by donors, with a recent surge in regional focus on resilience a possible partial outcome of donor agendas. An interesting facet of donor interventions was the apparent presence of “co-editing” (as mentioned by an interviewee) referring to instances where donors had already set out their plan of interventions, with cursory editing and rubberstamping of donor project descriptions and reports made by local counterparts to satisfy the requirement for local input. This contrasts to the more open co-production and co-design ideals of many intervention efforts (Dilling and Lemos, 2011; Jones et al., 2017; Vincent et al., 2018; Bremer et al., 2019), and as such draws attention to well-intentioned but likely misdirected strategies. Several respondents mentioned that perhaps donors did not fully understand the region or local/cultural contexts, with one person offering the recommendation: “do not bring [local partners] in at the end; [they] should be there at the start.”

Greater recognition of this need for localized climate information alongside local professional and cultural considerations is crucial. Toward these efforts, it was suggested that there be renewed attention to highlighting and exchanging best practices and success stories of how climate information is used, alongside information about financial savings (i.e., relevance to the economic bottom line), and other socio-economic benefits. While the general paucity of evaluation studies may make this difficult (Wall et al., 2017), it is an area for future priority. Furthermore, identification of the role of political awareness and changing political alignments as barriers suggests that climate service programs must be positioned more within independent/autonomous policy processes and institutional structures within the region. To minimize future challenges of legitimacy, as regional climate producers develop potential for local improvement and more contextualized information use (Guido et al., 2016, 2020; Mahon et al., 2019; CDB, 2020), it would be beneficial for experts such as those interviewed here to be more involved with climate information and service providers and/or regional boundary organizations to promote Caribbean ingenuity and innovation.

Concerns about donors are also related to a wider challenge of regional and national institutions being fragmented or siloed in their approaches to climate change and climate information use. Figure 2 shows that there has been a range of regional donor-funded efforts across the years, with more than 40% of these including a focus on climate information. However, the initiatives

are disjointed and carried out by different donors over time. It is perhaps with this in mind that respondents noted the need for donors to coordinate more effectively and reduce elevated levels of consultation fatigue and duplication (especially given low human resource capacity levels) and minimize the risk of promoting poorly aligned agendas. Some respondents also noted the need for renewed regional collaboration, particularly in the context of SIDS, given opportunities to further develop discussions and alignment with Pacific SIDS. In addition, respondents suggested that states and the region as a whole work to balance climate issues with other development priorities more effectively (given competing interests), and develop local expertise to take ownership of issues, rather than rely on external approaches and consultants.

Respondents also noted the role of human resources as a constraint for using climate information (see Table 3). The sparse numbers of overall staff, especially in climate services, is perhaps distinctive about SIDS/small states. However, human resource requirements also feature in, for example, European countries, where critical enabling factors were identified as “the existing level of resources, capacity, and expertise in the organizations” (Bruno Soares and Dessai, 2016, p. 99). Furthermore, Caribbean interviewees mentioned elevated levels of attrition within government agencies despite significant investments in skills training. Figure 4 highlights the relevance and strong connections of this factor with technological resources, financial resources, and local awareness of climate information. Thus, together with financing and data salience and credibility, there also needs to be a complementary focus on investing in local staffing and their skills.

Collectively, our results highlight numerous barriers and enablers that relate to credibility, salience and legitimacy and the need to address these through improved co-production processes. These goals reinforce the need to focus on strengthening capacity (and in some cases the remit) of NMHSs and regional boundary organizations to work across boundaries, recognizing that a focus just on the information deficit model of uptake will not be enough. This requires climate scientists and the users of climate information to engage more and to create better enabling conditions to bring this about: to listen, understand and respond to the local and sectoral needs of the region (Guido et al., 2016, 2020; Porter and Dessai, 2017; Gerlak et al., 2018; CREWS, 2019; Mahon et al., 2019; Matthews et al., 2020). In this vein, an important initiative is the Consortium of Sectoral Early Warning Information Systems across Climate Timescales (EWISACTs) (see CIMH, 2018; CDB, 2020; Figure 1), designed to improve sectoral alliances for climate resilience and develop a range of sector-specific climate products. While such an alliance requires attention to both the climate information provider and user sides to effectively share what is “credible, usable, and relevant,” it also requires broader social support and institutional design and incentives to change (Porter and Dessai, 2017).

To this end, the key roles of established factors such as loud voices/champions and legislative mandates, as well as respondent-suggested political will and leadership, and the influence of system shocks are noted as significant enabling factors in the form of catalyzing conditions (Ara Begum et al., 2022; New et al., 2022). While respondents did not identify where these loud voices should

come from, the prominence of critical climate-sensitive sectors such as agriculture, fisheries and tourism could be a starting point for seeking and encouraging champions. Interestingly, there may be several benefits from a renewed focus on the tourism sector due to its crucial position in the region, its dependence on the climate and private sector perspective on achieving a cost-effective value of climate information, and the high potential for public-private partnerships (for example, see Matthews et al., 2020; Mahon et al., 2021).

In terms of policy drivers, high level political will to promote more informed climate information use could have widespread effects throughout decision-making structures in countries. However, since many of the current conversations are retained within technical groups, this limits the awareness and motivation of politicians to improve the visibility and use of climate information. While the Caribbean Meteorological Organization (CMO) has plans for increased inter-ministerial discussions and sectoral strategic plans (Laing, 2021), there is a need to leverage these existing governance structures, learning from empirical evidence of barriers and enablers, to further coordinate a coherent strategic approach to adaptation in the region (Thomas et al., 2019). It is evident that there is yet a clear need for Caribbean governments to be more direct and detailed in their climate-related projects, programs, and policies.

Lastly, while this research has offered localized experiences and narratives regarding the wide possibilities of barriers and enablers of climate information use within the region, we recognize that having more climate information, or even having such a basic knowledge of experiences, is not sufficient to enable efficient uptake of climate information. This study does not suggest that Caribbean people *per se* are responsible for the ongoing challenges of climate information use within the region; rather, it reinforces the point that there are many interlinked enabling and catalyzing conditions that play a role in the awareness, applicability, and use of climate information. As well, while many of these conditions may have been exposed within this study, there are wider socio-economic and legacy structures in place within the region which mediate the observed conditions. These discussions merit consideration but are outside the scope of this study.

6. Conclusion

This research has investigated Caribbean-focused perspectives on the demand for and use of climate information within the region. Empirical evidence from semi-structured interviews was used to examine the understanding of common terms within the scope and timescales of climate-related decisions, the sources of and how climate information is understood, complemented by detailed local perspectives on barriers and enablers which mediate climate information use.

While Caribbean SIDS face severe climate impacts, locally relevant research on how climate information is viewed has been limited. This research provides insights which could not only assist climate adaptation processes within the region, but also offer relevance for other SIDS. We note that this study complements

existing research—Caribbean initiatives have been developing and pursuing a range of climate-related efforts—and within this process, the utility and importance of climate information is evident. However, respondents identify numerous barriers, many of which are well-established in the literature and persistent over time. Viewpoints on Caribbean contexts of climate information use underscore the fact that knowledge itself is not tantamount to immediate mobilization and uptake. The perceptions captured in this research highlight the importance of greater focus on developing locally appropriate agendas of action that are clear about their goals, across multiple timescales. Consideration of the range of enabling and catalyzing conditions identified for effective utilization of climate information is necessary, particularly the need for tailored capacity strengthening, focus on roles of political factors and champions, co-production, and donor coordination. As well, it should be noted that since many of the barriers identified and confirmed within this study are similar to findings in other regions, there is a wider research need to reflect on the persistence of certain factors and conditions and the impact that this may have on making global progress on adaptation and resilience.

As the Caribbean continues to face climate-related challenges, greater attention is needed on limiting the persistence of barrier factors and encouraging supporting factors, in tandem with better understanding and attending to the availability and accessibility of locally relevant climate information. Such an improved focus on enabling and catalyzing conditions of climate information use should enhance the design of an effective adaptation agenda and signal the need for increased and improved attention to SIDS as likely canaries in the climate coal mine.

Data availability statement

The data that support the findings of this study are available from the corresponding author, DSD, upon reasonable request.

Ethics statement

A Research Ethics Review was completed, within which the research was deemed low-risk, and as such did not require formal review and approval by the LSE Research Ethics Committee. The participants provided their written informed consent to take part in this study.

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Author contributions

DSD, DC, and SD contributed to conception and design of the study. DSD designed the interview protocol, undertook the interviews, performed the data analysis, and wrote the first draft of the manuscript. DC and SD provided substantial manuscript rewrites, comments, edits to all sections, and elements of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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