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REVIEW

Participatory justice and climate adaptation for water management in Small Island Developing States: a systematic literature review and discussion

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Abstract
As the impacts of climate change increase, Small Island Developing States (SIDS) in particular shall face increasingly significant adaptation challenges. Past climate adaptation efforts within SIDS have had limited success. As such, the purpose of this systematic literature review has been to identify areas of importance for facilitating climate adaptation, particularly within Small Island Developing States (SIDS), and more specifically, to assess the extent to which participatory justice within decision-making processes is recognised as an important component of climate adaptation through the lens of water management. This review process utilised the SPIDER tool to guide the literature search across SCOPUS, Web of Science and EBSCO host databases, generating 495 publications that were reduced to a total of 70 sources guided by PRISMA, informing the review's results and discussion. Thematic analysis of the selected studies was applied, utilising the Values-Rules-Knowledge framework. Through this analysis, five principles were created and comprise the major conclusions of this review: (1) ensuring community engagement, (2) expanding available options through local experimentation, (3) ensuring that monitoring and evaluation of adaptation initiatives are taken seriously, (4) adopting decision-making mechanisms that are systems-oriented and inclusive, and (5) investing only if there is a long-term commitment to protecting SIDS. It is hoped that these principles can serve as a comprehensive guide for funding agencies, applied projects and research aiding climate adaptation within SIDS.

Keywords Climate change · Sea level rise · Decision-making · Community engagement · Water management · Small Island Developing States

Introduction

Climate change is already resulting in unpredictable climate patterns and extreme weather events (Seneviratne et al. 2021; Lee et al. 2021). As climate change intensifies, this will result in wide-ranging impacts on society and ecosystems, but the impacts vary greatly between different locations. It is widely acknowledged that atolls, especially those in Small Island Developing States (SIDS) like Kiribati and the Marshall Islands, with limited financial and other resources, are likely to experience some of the most severe effects because of climate change (Mycoo et al. 2022; Petzold et al. 2023). In many such locations, the impacts of climate change intersect with pressures from economic development and increased population densities (Storey and Hunter 2010). This indicates the importance of social dynamics and resource management for ensuring resilient communities and climate adaptation. In fact, despite much

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ingenuity and resilience of local populations, climate change is likely to significantly "sharpen social and cultural issues of equity" in SIDS (Weir et al. 2017, p.1017).

The United Nations includes 57 nations in their list of SIDS, that are characterised by their remote geography and often face significant social, economic and environmental vulnerabilities (United Nations 2023a). Climate change is a particular threat in these locations (see Thomas et al. (2018)), and participatory approaches to planning are often suggested as a useful approach to reduce such vulnerabilities (Williams et al. 2020). Participatory justice can be defined as "respect for people's human dignity and autonomy in the face of the power of government to confer, withhold, or reduce vital social benefits. It recognises people's deep need to be treated as bearers of rights entitled to agency in decisions which have a fundamental impact on their lives and wellbeing" (Liebenberg 2018). This concept can be linked with climate justice, which recognises that "climate change impacts people differently, unevenly, and disproportionately, as well as redressing the resultant injustices in fair and equitable ways" (Sultana 2021). With this in mind, this article reports on a systematic literature review of how participatory justice in decision-making processes relating to water management can support climate adaptation in SIDS, which are particularly vulnerable locations, especially in coastal areas and atolls.

Other studies with similar goals have included the work of Hagedoorn et al. (2019) who undertook a quantitative analysis of community adaptation engagement within SIDS. Other reviews specifically have included the work of Thomas et al. (2020) who focus upon climate change impacts, adaptation and mitigation, as well as consideration of loss and damage and climate justice, and the work of Robinson (2020) who focuses upon the impacts, implications and responses to climate change in SIDS, pointing to the knowledge, framing and gaps within the literature that require further research.

Distinct from the contributions of Thomas et al. (2020) and Robinson (2020), this review translates our analysis of the literature into recommendations for planning climate adaptation efforts that provide a more comprehensive approach to climate adaption, drawing on lessons identified through our systematic review. While various ways of dealing with this nexus of dilemmas have been proposed, there does not seem to be evidence of any such comprehensive integrative methods to have been implemented successfully in practice. Approaches in practices have rather addressed some of the dilemmas, but not all dilemmas all together.

Climate impacts in Small Island Developing States

While there has been a call for greater research into and evidence of the likelihood of mass climate migration from the Global South to the Global North, with concerns identified around security risk framings offering justifications for securing Global North borders (Boas et al. 2019), it is thought that climate change will lead to widespread displacement of people from low-lying areas of SIDS due to sea level inundation, high risks of coastal flooding caused by extreme weather events, stressed freshwater supplies, loss of coral reef and damage to ecosystem health, and persistent heat leading to heat stress (Hoegh-Guldberg et al. 2019; Magnan et al. 2022; Mycoo et al. 2022). In atolls in SIDS, which are almost by definition low-lying, the focus is on climate adaptation rather than mitigation for two reasons (Cassin et al. 2022):

1. Firstly, they are not responsible for the ongoing increase in global temperatures, and they have no meaningful means of mitigating climate change by reducing greenhouse gas emissions, due to their small size.
2. Secondly, they are generally some of the most vulnerable locations to climate change impacts, both due to high densities of population and economic activities in coastal areas, as well as their high reliance on natural assets, especially as many in these locations remain reliant on subsistence livelihoods.

While sharing a vulnerability to climate change, SIDS represent highly diverse contexts, both geographically as well as socially and culturally, with a variety of adaptation strategies being implemented (Klöck and Nunn 2019) and it is not surprising therefore that climate change impacts vary considerably depending on the nature of the islands, for example, higher islands have a different risk profile to atolls. Atolls are particularly vulnerable to sea level rise and storm surges that not only risk homes and infrastructure, but sea level rise can claim very significant if not all land in these locations through inundation (Sabünas et al. 2021), as well as threaten freshwater systems in the meantime (Moglia et al. 2008). Higher islands (incl. volcanic islands) are also vulnerable to sea level rise and storm surges, but to a lesser extent, plus tropical cyclones can also significantly threaten economic activity, livelihoods and lives (Sabünas et al. 2022). Importantly, it has also been estimated that climate change will drive annual flooding events that are likely to leave atolls uninhabitable by the mid-twenty-first century (Storlazzi et al. 2018).

Challenges of economic development and population growth in atolls

Aspirations for a modern lifestyle, population density and limited resources cause severe pressures on the natural environment in atoll contexts (Thomas 2003). However, this tension goes both ways, as limitations on resources,

especially water, also put constraints on economic development (Thomas 2003).

Economic development also promotes the health and wellbeing of communities. For example, agricultural diversification, i.e. in the case of many atolls moving away from a nutritional over-reliance on fish and coconuts, is important for creating sustainable livelihoods as well as access to fresh produce (Charlton et al. 2016). Efforts for economic diversification and development however are limited by challenges associated with "resource management, pollution, coastal erosion, water quality control, renewable energy production, family planning, and global warming" (Thomas 2003, p.1). Climate change threatens access to water and therefore risks water and food security (Gohar et al. 2019). As such, it is not surprising that climate change has been noted as the greatest threat to the environment and therefore to economic development in these contexts (Ghina 2003), something which has also been echoed by the Pacific Islands Forum (2018).

In an attempt to promote more resilient communities in these types of location, the Asian Development Bank suggests that a combination of participatory urban development, a systems approach to urban planning, improved institutional arrangements, and strengthened human and financial resources, is a key to allow for economic development to occur even during severe climate change scenarios (ADB 2013), while a United Nations (2023b) Task Force argues for a USD1.5 trillion investment fund to bridge the infrastructure gap in SIDS and other low-lying areas in underdeveloped countries.

The need for participatory justice in climate adaptation

A study undertaken by Piggott-McKellar and colleagues (2019) identified three sets of barriers to climate adaptation including socio-political barriers, resource barriers, and physical systems and processes, with socio-political barriers identified as the most significant, entailing the social, cultural and political context of project design and implementation. The impacts of climate change do not impact communities evenly, and there is a strong connection between social justice and climate adaptation (Wagle and Philip 2022). Furthermore, climate adaptation efforts need to consider how communities engage with and perceive climate adaptation interventions to be effective (Kuruppu and Liverman 2011). Calls for Indigenous communities to lead data gathering, along with the design and implementation of community-based assessments, have been made to ensure that co-production of knowledge takes place to aid governance and effective climate adaptation (Bronen et al. 2019). Recognising the assets that are local communities' resilience and innovation in climate adaptation efforts is also advised (Clarke et al. 2019). But the commitment to interventions from the community is not enough, and it has been found that to ensure successful interventions, there also needs to be a combination of strong top-down leadership, some level of external funding, government commitment and ongoing involvement from key stakeholders (Anguelovski et al. 2014). The element of ongoing engagement also appears significant; as Westoby et al. (2020) assert, externally funded projects at some point run out of funding and interest wanes, acknowledging that at this point projects often collapse with these communities left to face ongoing challenges.

Fazey and colleagues (2016 p.39) show based on the evaluation of multiple climate adaptation case studies that "world views, values, culture, power relations, availability of key assets, and the normative goals or perspectives of what constituted 'successful' adaptation" have a key influence on climate adaptation outcomes in complex but interrelated ways. Fazey et al. (2016) also argue that there are three important principles when planning climate adaptation interventions (using a pathways approach) or responding to shorter-term challenges, i.e. to consider:

1. Longer-term issues, and to avoid closing off key options or locking in undesirable futures.
2. The diversity of perceptions or experiences of alternative adaptation pathways, to allow for better managing resistance and inertia to solutions.
3. How to best enlist the imagination of possible futures, so that stakeholders can co-create the future they want.

These insights all point to the importance of involving the community and government as key equal stakeholders when designing climate adaptation actions. This article explores this topic in the context of SIDS, with a particular focus on atolls, which are at the frontier of climate change impacts (Amores et al. 2022; Cauchi et al. 2021; Birk and Rasmussen 2014; Islam et al. 2022; White et al. 2007).

Scope and structure of this article

The aim of this study is to understand how participatory engagement to support climate adaptation planning can occur, in the context of atoll-specific and SIDS-specific vulnerabilities to climate change with a focus on water management, remote geography logistics and capacity constraints as well as the cultural and social dynamics of small islands. Therefore, our research question is:

> What considerations and steps have been identified as useful for aiding participatory justice in decision-making processes relating to climate adaptation especially in relation to water management in atolls in SIDS?

The focus is on atolls that are at the frontier of climate change impacts, especially in relation to sea level inundation

which will lead to significant loss of land, and importantly, due to storm surges and shallow groundwater lenses, urgent threats to water supplies (Amores et al. 2022; Cauchi et al. 2021; Birk and Rasmussen 2014; Islam et al. 2022; White et al. 2007).

To address this question, we interrogate academic literature based on a systematic literature review methodology, described in the "Material and methods" section, guided by PRISMA (Moher et al. 2015). The scope of this systematic literature review included publications relating primarily to SIDS, and additional literature with findings applicable to SIDS which focus on coastal geographic contexts more generally specifically discussing climate adaptation and decision-making related to water management.

The "Results and discussion" section (the results) sets out the core of the literature reviewed. In this section, following Colloff et al. (2018), we used the Values-Rules-Knowledge framework to categorise the factors identified through our review, that influence decision-making contexts and that are required to support adaptation. This is done to better understand how climate adaptation can be constructively reframed to allow new adaptation pathways.

In the "Synthesis: five principles for adaptation" section (the discussion), we draw on the reviewed literature to identify the five principles that should be used in climate adaptation strategies in atolls in SIDS. To increase the chances of successful climate adaptation, it is recommended that these principles inform the approach of funding agencies.

Material and methods

The scope of this systematic literature review included publications relating primarily to SIDS, and additional literature with findings applicable to SIDS which focus on coastal geographic contexts more generally specifically discussing climate adaptation and decision-making related to water management.

Although earlier reviews of climate adaptation in SIDS do include aspects of water management in SIDS (i.e. see Mycoo et al. (2022), Petzold et al. (2023), Klöck and Nunn (2019)), we believe that the present paper is the widest review to date of that specific subject.

Search and selection criteria

The literature search was guided by the SPIDER tool (Cooke et al. 2012) encompassing qualitative, quantitative and mixed methods studies, utilising the Sample, and Phenomenon of Interest component of the tool (Table 1). The review process was undertaken utilising EndNote and Covidence. The databases utilised for this review included Scopus, Web of Science and EBSCO host. Search terms were identified based on using starting words (climate adaptation, atoll, small island, resilience, etc.) in Scopus to identify a set of articles, as a basis for refining the terms further. This was done by identifying words in titles, and abstracts—and reading key papers in full—to try to make sure that we could find those papers that were useful for our study. We also note that there is not a great deal of literature on this relatively narrow topic, so experimenting with or refining the search terms did not yield a significant return in terms of additional papers.

Inclusion criteria

This systematic literature review included studies engaging with community members' involvement in decision-making processes; studies focusing upon climate adaptation; studies addressing issues of water management on islands or coastal areas; studies that were qualitative, quantitative and mixed methods; and studies published in English. While not intentional, it was noted that the literature generated within the search all happened to be published after the year 2000.

Exclusion criteria

Newspaper articles, trade publications, magazines, studies focusing upon Western Educated Industrialised Rich Democratic (WEIRD- Henrich et al. 2010) locations, which encompass the Global North, or developed nations. Exceptions were applied to sources by van Slobbe and colleagues (2013) and Lawrence and colleagues (2020) due to the high

Table 1 Search terms

SPIDER tool	Search terms
Sample	"atoll" OR "low lying" OR "low-lying" OR "small Island"
Phenomenon of Interest	"resilien*" OR "climate adapt*" OR "climate change" OR "climate mitigate*" AND "decision mak*" OR "participa*" OR "stakeholder" OR "community represent*" OR "govern*" AND "water manag*" OR "water security" OR "water supply" or "groundwater" OR "freshwater" OR "hydrol*"

level of applicability to the issues under study. Studies primarily focusing upon physical or geographic assessments of climate vulnerability were excluded from this review. It is acknowledged that the pragmatic decision to exclude literature on climate adaptation that do not focus upon water management limits insights from these studies that could have some relevance also for water management.

Data extraction and analysis

The original search results were comprised of 495 publications which was reduced to 442 after removing duplicated sources. Abstract and title screening undertaken by two authors further reduced this total to 372 sources. The application of inclusion and exclusion criteria was undertaken by all three authors with discussions taking place to reach consensus on sources that one or more authors identified as potential exclusions, resulting in a total of 62 sources, with an additional five opportunistically included from outside the review (Crisman & Winters 2023; Davies 2016; Tanavud 2007; Veron et al. 2019; Walker 2019) due to the authors' knowledge of these sources and their high level of relevance, and a further thirteen included from outside the review (Duvat et al. 2021; Granderson & Leotaud 2021; Herrera Arango et al. 2022; Hiwasaki et al. 2015; Kalaidjian and Robinson 2022; Kepel et al. 2023; Longman et al. 2022; Love et al. 2023; Mercer et al. 2012; Mustelin et al. 2013; Nalau et al. 2018; Weir et al. 2017; Werners et al. 2021) recommended through the peer-review process, resulting in a total of 79 sources informing the results and discussion. Figure 1 outlines the PRISMA flow diagram. A thematic analysis (Liamputtong and Ezzy 2009) utilising open coding (Strauss and Corbin 1990) was applied to the key findings of each of the sources. The original themes identified included benefits of going beyond traditional adaptation measures, achieving effective management and governance, community engagement, importance of taking local context into account, responsive adaptation to changing risks, the value of a social-ecological frame, balancing environmental and economic needs, potential to address local inequity through climate adaptation measures, broader economic questions

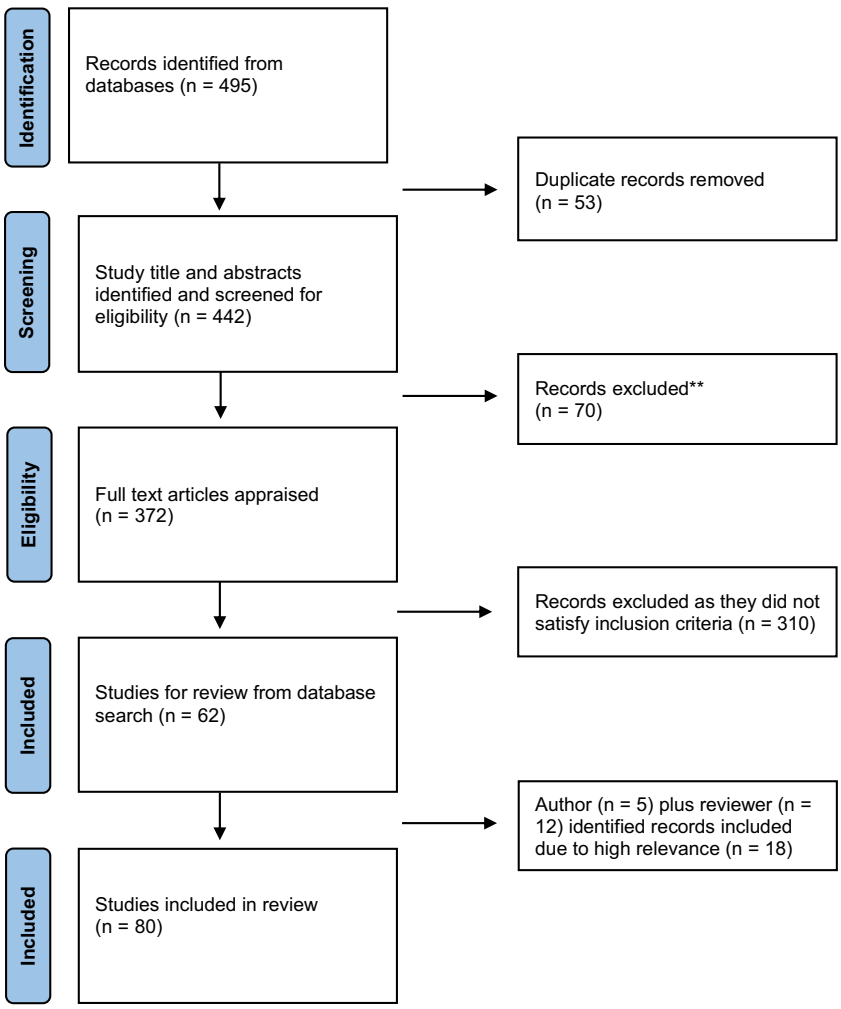

Fig. 1 PRISMA diagram

of climate justice, and finally, challenges and possibilities surrounding migration. Within our next step of the analysis process, these themes were placed within the broader Values-Rules-Knowledge framework that focuses upon the interactions between and influence of values, rules and knowledge in decision-making for adaptation initiatives developed by Gorddard et al. (2016). This is a heuristic to disentangle the factors that contribute into a decision-making context and has been used for guiding climate adaptation, specifically by analysing, reframing and defining adaptation pathways (Colloff et al. 2021). Here, it provides the themes by which we have organised the data and insights of the review. The themes are defined as (adapted from Colloff et al. (2021) and Colloff et al. (2018)):

- Values: "stated preferences, ethical precepts and principles that determine the way people select actions and evaluate events or those preferences"
- Rules: "prescribed and proscribed actions and the associated bodies of laws (formal rules: regulations, legislation, treaties, ordinances and socially shared rules, and informal rules: norms, practices, taboos, habits, heuristics, for how rules are applied and interpreted"
- Knowledge: "mix of evidence-based (scientific and technical) knowledge and experiential, understandings, meanings-based knowledge that forms part of constructed knowledge systems in the decision-making process"

Results and discussion

The results convey key considerations relating to climate adaptation of SIDS that have been structured according to an adjusted form of the Values-Rules-Knowledge framework (Werners et al. 2021; Gorddard et al. 2016) outlined above. The way that we have applied this framework is explained at the start of each main section. It should be acknowledged that this is a relatively recent area of research, and as such there is a need for further research that can strengthen the available evidence to enhance the confidence and generalisability of what is found.

Values that support adaptation

Here, we identify key value dimensions relating to equity and justice in climate adaptation projects in low-lying islands in SIDS. We associate equity and justice with values, recognising the call for equal rights and justice within the United Nations Charter (UN 1945) as representative of elements that comprise a global value system.

Equity and fairness

In response to Sustainable Development Goal 6.1, that aims to ensure equitable access to drinking water by 2030, Anthonj and colleagues (2020) examined the geographical inequalities in relation to drinking freshwater sources and services within the Solomon Islands, recognising that this is a ubiquitous challenge for SIDS and Pacific Island Countries. Their research found considerable inequality in water access on the geographical bases of an urban vs rural location, living in provincial area, a central vs a peripheral location, and within an international context of being removed from major landmasses and economies (Anthonj et al. 2020). Beyond geographic bases for inequality, research undertaken by Herrera Arango and colleagues (2022) found the most significant water shortages in places with historical inequalities and the neo-colonial privatisation of water through formal and informal irrigation infrastructure. Baarsch and Berg (2015) further identified an inequitable distribution of adaptation-based resources pertaining to water catchment and storage equipment *within* the community leaving some members highly vulnerable, highlighting the importance of understanding the context within which adaptation measures are implemented.

In response to limited economic resources held by SIDS for addressing the impacts of climate change including tidal flooding and inadequate water supply, and failed government and NGO strategies to address flooding and lack of access to fresh water, Jamero and colleagues (2018) see the need to build climate resilience within communities to address the socio-economic drivers of vulnerability through the implementation of community-based adaptation (CBA), highlighting the need for community participation and adequate funding for CBA success. According to the United Nations' Adaptation Gap Report 2022: Too Little, Too Slow, the required amount of climate adaptation funding for developing nations per year between now and 2030 is US$202 billion, with US$28.6 billion generated by developed nations in 2020 (UNEP 2022a, b).

Furthermore, Singh and colleagues (2022) whose study focuses upon water, waste and infrastructure, assert that competition over scarce resources requires an inclusive approach to risk governance and that equitable circulation and distribution of costs and benefits of goods and services be aimed for. Much of which should be funded by international compensation agreements (Mace and Verheyen 2016; Calliari 2018; United Nations 2020).

Interconnected social-ecological values

In the face of climate change, SIDS are facing significant challenges balancing economic development with environmental protection, especially as small island ecosystems are

often vulnerable, unique and contributing disproportionately to global biodiversity as mapped in the study undertaken by Veron and colleagues (2019). This raises values-based questions around how to balance the needs of nature and people in a way that allows both to thrive, even under significant stress caused by climate change. However, social-ecological systems are connected and dynamic with non-linear features, high levels of unpredictability, and can switch from one steady state to another at short notice (Walker 2019). It is therefore not surprising that a significant body of literature considers climate adaptation in SIDS from a social-ecological perspective, because social and ecological values are so intertwined.

In line with this thinking, and in response to the challenge of ecosystem restoration set by the United Nations, Elias and colleagues (2022) highlight the importance of people-centred strategies so that human wellbeing along with environmental benefits can be achieved, and in their study have developed people-centred rules designed to enhance the tenability of ecosystem restoration, inclusion, poverty reduction and delivering SDGs. In relation to water supply, groundwater within SIDS has not been successfully managed in the face of climate- and population-based challenges; however, it is argued that applying a social-ecological framing onto resource systems, like groundwater systems, provides a mechanism for decision-making to help consider the inextricable link between this natural system and social system (Bouchet et al. 2019).

Sustainable livelihoods

The overarching challenge to water management plans in the Caribbean Region according to Cashman (2014) has been balancing environmental resource provision, specifically focusing on water resources, with economic growth and social wellbeing, entailing also a balance between policy and regulation alongside service provider independence. In the agriculture sector, and particularly small-scale agriculture such as that found in St Lucia, adaptation to sustainable agriculture, diversification and commercialisation was a way to address the twin challenges of a globalised market and climate change (Mannke and Rath 2011). To inform policy around natural resource management, Drakes and colleagues (2020) demonstrated, through their investigation of water demand within the Caribbean's tourism sector, the value of applying a cross-scale, scenario-based framework that is responsive to shared socio-economic pathways, representative concentration pathways and national storylines. Calls to adapt economic activity and reduce its vulnerability to climate change, thereby protecting sustainable livelihoods, have also been raised regarding the tourism sector, often one of the most important employment sectors of Small Island Developing States (Klint et al. 2012).

Responding to the need for further development of planning processes for climate compatible development more generally, Wise and colleagues (2016) devised a process to assess rural livelihood adaptation strategies, finding that decision-makers' capacity to tackle systemic drivers of vulnerability would be improved through further learning processes. Wise and colleagues (2016) also acknowledge that the need to build infrastructure to deliver health, education, income generation and food security services can lead to maladaptation in cases where this infrastructure development burdens vulnerable groups disproportionately, reduces adaptation incentives and increases carbon emissions, and therefore calls for flexibility as part of this process to mitigate this risk.

Financial constraints

Funding for adaptation when made available is due to the recognition of doing so as an important issue to be addressed and therefore aligned with values. Values also inform processes of allocating funding and prioritising particular adaptation initiatives for funding. Rules also interestingly intersect and can be reflective of values aligned with funding. Of fundamental significance when formulating climate adaptation strategies is the limited capacity of SIDS to finance adaptation measures, with Gheuens and colleagues (2019) emphasising the need for financial support from developed nations through the UN Convention on Climate Change. Another call for external support is found in the work of White and colleagues (2021), who recognise in their research on marine protected areas in Indonesia that are yet to be legally protected and have low levels of implementation, that the complexity of science and management needed to achieve the enhancement of fisheries, biodiversity protection, climate adaptation and the protection of community livelihoods and traditional practices is beyond stakeholder comprehension, that multiple jurisdictions are needed for implementation of these initiatives, and that these processes are only possible with external support.

The task for researchers in this area is outlined by Busby (2021), who in framing climate change challenges in terms of climate security, argues that while much research has been undertaken in this area over the past 15 years to identify risks, insufficient insights have been proposed for aiding fragile states, considered as those without sufficient resources and political capacity for successful climate adaptation (Buhaug et al. 2008, as cited in Busby (2021). Fragile states are those without resources and capacity politically for effective climate adaptation, and the Pacific Islands Forum (2018), representing most of the states of the South Pacific, has recognised through the Boe declaration the role of democratic governance, regionalism and collaboration as

key mechanisms to address collective security concerns like climate change.

The rules that support adaptation

Rules are dually defined as "*Rules-in-use* include norms, practices, taboos, habits, heuristics and have the form "if in situation *a*, undertake action *b*" and provide evolutionary building blocks for society. Rules-in-form include regulations, legislation, treaties and ordinances. Related to formal and informal rules" (Gorddard et al. 2016 p.62).

Governance that deals with uncertainty

In the context of highly complex socio-technical systems and limitations in available knowledge, there is always uncertainty in the efficacy of solutions, and institutions and community support that enable solutions may need to evolve around implementation. This type of adaptive governance is critical for enabling climate adaptation in atolls.

To illustrate this, despite the development of policy paradigms designed to address water insecurity, Belmar and colleagues (2016) state that progress towards achieving water-related millennium development goals and reducing water-related risks has been limited. They examine the applicability of these policy paradigms within SIDS, finding the adaptive management paradigm to be the most beneficial due to its lesser reliance on transformational governance capacity (Belmar et al. 2016). However, it should be noted that adaptivity and transformation can be closely linked.

Heath and colleagues (2014) further highlight that remote regions, especially small islands (outer islands in the context of SIDS), are the most vulnerable to water security issues and that human activities impact both the quality and quantity of groundwater which is often a main source of water supply. They also stress the importance of an adaptive and integrated approach to management and governance to address threats to food security, water security, and energy security.

While not specifically SIDS focused, the work of van Slobbe and colleagues (2013) responding to failed responses to storm surges in the past relied upon traditional engineering, and Swanson and colleagues (2010) illustrated how adaptive practices, such as soft systems engineering and decentralised government, can utilise aspects of the existing natural environment to build resilience in future, climate-changed, environments with regard to storm surges, and water and agricultural management respectively. Lauer and colleagues (2013) further illustrate how such adaptive governance has been applied in the Solomon Islands after a 12-m tsunami, resulting in low-probability risk being accepted in exchange for prioritised benefits, making for an agile governance and implementation environment.

To this end, Heath and colleagues (2014) highlight the need to ensure socio-political relations are addressed, especially in relation to mitigating flood risks, improving water security and ensuring sustainable livelihoods, and suggest a human geography analysis that encompasses political economy and governmentality to fully appreciate socio-political relations.

Veitayaki and colleagues (2017) stress the need for comprehensive legal frameworks to accompany decision-making and implementation enforcement. Similarly, Kalaidjian and Robinson (2022) point to the diverse ways in which allocation criteria for climate adaptation funding is operationalised resulting in poor outcomes for SIDS. Mycoo (2018) whose study focuses on water governance challenges points to the need to curb both poor management and excessive use, and to take the impact of unique island geography on water resources into account. These insights suggest that what is important is not just the mapping and extent of trust relations between the political elements, but more so the *political will* to drive decision-making and implementation across an adaptive governance space.

Water quality challenges for ecosystem and human health faced in Kiribati have been difficult to address due to insufficient monitoring and observation that are needed in an ongoing capacity, particularly given increasing population pressures, urbanisation and climate stress faced there (Graves et al. 2021). Given the significant number of climate-based challenges facing low-lying islands, the need for policy and decision-making to engage comprehensive adaptation strategies is clear, with Bera et al. (2022) asserting from their study of Sagar Island in West Bengal facing challenges including flooding, that innovative technology, improved healthcare and communication, and robust infrastructure can enhance the ability to adapt (Bera et al. 2022).

Empowering the community to support adaptation

Regarding SIDS' responses to disaster management and water service restoration and resilience, Eudoxie and Roopnarine (2017) and Dey and colleagues (2022) acknowledge the need for broad stakeholder engagement, incorporating all facets of the local community, for effective implementation. While Eudoxie and Roopnarine focus on comprehensive engagement for the formation of effective policy and governance, Dey and colleagues (2022) point more to the need for local mobilisation as being a critical element for successful implementation. One rationale for this is the observation from Balaei and colleagues (2019), that strong social capital can dramatically speed up local disaster responses, in their case rebuilding water supply over 80 islands, but also that bottom-up facilitation can lead to a sense of ownership of the recovery and implementation process (Cuthbertson et al. 2019), particularly if the process is developed with, and for,

local cultural norms (Ibell et al. 2015; Cuthbertson et al. 2019), allowing for local governance supported by local laws (Davies 2016). De Suarez and colleagues (2014) and Rand and colleagues (2022) support this by acknowledging the significant role that community must play for water systems to be resilient to climate change adaptation. Granderson and Leotaud (2021) have found that when green and blue infrastructure is owned and delivered by civil society, there is potential for providing holistic solutions addressing the broad spectrum of climate adaptation needs.

In terms of specifics, Kuruppu's (2009) study of water management in Kiribati found that accounting for local politics and power struggles, specifically within her case study, recognising the positive or (often) negative influence of the local Churches on adaptation capacity was fundamental for achieving the greatest outcome for management and implementation. This indicates the importance of ensuring the buy-in and positive influence of local institutions when developing adaptation strategies.

The importance of engaging with community members can also help to overcome cognitive barriers that can prevent adaptive behaviour, as highlighted in the work of Kuruppu and Liverman (2011), who in their study of Kiribati applied a cognitive model, and found that when personal belief in their capacity or self-efficacy to adapt to water stress is present, intentions within individuals to adapt become strong, though this sense of self-efficacy can also be overly confident resulting in a lack of adaptation.

Breaking down silos

With climate change likely exacerbating already difficult conditions in small and tropical islands such as Sint Maarten, Vojinovic and Teeffelen (2007) highlight the need for integrative management plans relating to storm water management, that include the community, town planners, economists, lawyers, emergency services, engineers, surveyors, contractors for hazard reduction, operational management and post event recovery. The variety of expertise required to navigate climate-based challenges in small tropical islands is also highlighted by Hernández-Delgado (2015), who call for strategies to connect all levels of government and outline the myriad sectors needed to allow adaptation strategies to address socioeconomics, ecosystem protection, land use planning, health and safety, and conservation simultaneously. Some of the challenges posed regarding climate-based policy adherence within the Caribbean, and SIDS more generally emerge from governance silos that result in an unwillingness to share data, reduced political potency, limited funding and a lack of accountability, requiring all sectors and all government collaboration to be resolved (Scobie 2016). We also note reports that some island governments, notably those of Vanuatu and Samoa, have made a conscious and reasonably effective effort to get around this siloing by strengthening the central agency dealing with climate change (Weir et al. 2017). With a focus on Jakarta, Goh (2019) outlines the issue of urban flooding and advocates for a multidimensional and multivalent approach, taking into account the perspectives applied to this issue of urban ecological change from within biophysics, urban governance and socio-politics, stressing the need to be conscious of power relations and ensuring justice as significant urban and environmental plans are put forward.

The knowledge that supports adaptation

To support adaptation in low-lying atolls and other SIDS, it is important that the right knowledge is available to government planners, donor agencies and local communities when they make important decisions. This has been a key finding throughout the research, particularly focused on by Comte et al. (2016), Odemerho (2015) and Al Masud and colleagues (2018), all of whom not only positively frame utilising local knowledges in water management systems, but also point to its necessity. Failing to do so can leave projects open to failure in the long term when funding for the externally imposed governance and/or technology dries up. It is worth noting some literature that was not captured by this review's search terms, that focuses upon the value and role of Indigenous knowledge in climate adaptation including a study by Nalau and colleagues (2018) on the underutilised potential of Indigenous and Traditional Knowledge for Ecosystem-based Adaptation. A study by Hiwasaki and colleagues (2015) identified how Indigenous knowledge imbued within folklore, customary laws, local food, materials and structures, and observations of environmental and celestial body changes facilitates climate adaptation. A study by Mercer and colleagues (2012) highlights the value of Ecosystem-based Adaptation informed by local or indigenous knowledge. Crisman and Winters (2023) also note that constructed wetlands (a type of Ecosystem-based Adaptation) are effective for providing treatment of wastewater, with added benefits of recreation and ecosystem conservation. However, Weir et al. (2017) note that through urban migration, much local knowledge is being lost, or becoming ineffective, as those able-bodied for implementation now reside in loose communities around urban centres. Kepel et al. (2023), based on a study of a low-lying island in Indonesia, Tunda, note that the community's understanding and knowledge of sustainable water management is a crucial aspect of water security (in Tunda they found that only 30% of the population had this knowledge), and that effort should be made to educate residents about the required practices and governance.

An evidence-based systems perspective

Management strategies required for guiding Water, Sanitation and Hygiene development in Pacific Islands (a key part of climate adaptation strategies in atolls), identified by MacDonald and colleagues (2017), need to be evidence-based and achieve multiple goals, i.e. to demonstrably improve health and wellbeing, as well as ensure natural resources protection, providing access to safe drinking water. Aligned with achieving evidence-guided management strategies, MacDonald and colleagues (2017) highlight the value of assessing different "system" approaches to successfully complete such planning activities.

An evidence-based approach to climate adaptation also requires scientific knowledge, and for water management this in particular concerns and understanding of climate change likely scenarios of variability and drought in the future. Longman and colleagues (2022) highlight the potential for regional collaboration, via process of knowledge co-production and knowledge exchange, as a way to build useful knowledge products that can inform climate adaptation.

A systems approach is also adopted by Chan and colleagues (2020), who propose the use of a Bayesian Belief Network model comprised of water and sanitation systems as they relate to climate and weather, water sources, hydrogeology, behaviour and decision-making. Bayesian Belief Networks are a computational representation of a system, often based on participatory processes, and usually based on a mix of elicited expert knowledge, stakeholder perceptions and statistics, thereby becoming a repository of transdisciplinary knowledge. Setting up such a system usually requires specialised expertise, but its use for ongoing evaluation and risk assessment is fairly straightforward. Here, the Bayesian Belief Network is used to support decision-making related to water resources in the Solomons to account for the relationship between sanitation, community behaviour and climate impacts. The application of the Bayesian Belief Network within this study utilised and integrated a diverse set of sources, including quantitative data on water, sanitation and hygiene from household surveys and qualitative data on social, cultural and environmental knowledge to aid decision-making within institutions around water supply and sanitation improvements.

Accounting for interactions between social, environmental and economic elements of socio-economic systems is also highlighted by Sahin and colleagues (2021) who used a Bayesian network model in conjunction with participatory knowledge elicitation so as to provide an integrated assessment of the impacts of a series of climate adaptation interventions and to offer support for how decisions are made while taking into account how decisions can affect other system elements.

Given the limited resources (especially financial) and expertise that SIDS may access, the importance of prioritising geographical areas of vulnerability within climate adaptation strategies is heightened. Therefore, in their study on coastal governance of small islands within the context of Indonesia, Glaser and colleagues (2018) call for targeted governance and propose a framework that identifies key governance-related components of small-island social-ecological systems that address both vulnerabilities and opportunities. They identify the benefit of applying a whole-systems approach by visualising the relationships between social, environmental and economic changes for improving understanding of vulnerabilities and opportunities (Glaser et al. 2018); which also speaks to the need for interdisciplinary approaches in adaptation research, covered in Mustelin et al. (2013).

Understanding of place and context

The diversity of physical and socio-cultural contexts in atolls makes it difficult to generalise when it comes to climate adaptation, and within this review, a variety of geographies are included. What may work in one location may not work in another, and this necessitates a comprehensive understanding of place and context. This is clearly apparent in the work of Fleming and colleagues (2019) who focus upon Water, Sanitation and Hygiene strategies to enhance climate resilience within the Solomon Islands, demonstrating that "one-size fits all" approaches are inadequate, with a need to take local contexts into account. Similarly, Roy and colleagues (2022) whose work focuses upon the impact of sea level rise point to past adaptation measures not addressing desired outcomes due to a lack of consideration of the local context, community-led adaptations and perceptions, highlighting the necessity of engaging with community perceptions, socio-economic and geographic contexts.

In their assessment of water development projects in Tarawa, Kiribati, Moglia and Perez (2007) recognise past failures appearing to result from a lack of accounting for social dynamics, the local hydrology and geology, and local organisational capacity. In response, they advocate for community participation within project design that could be aided through the utilisation of Bayesian Belief Networks (see previous description of this methodology) detailing interactions to identify important vulnerabilities and requirements. These modelling activities were quite successful in integrating a comprehensive understanding of the local context, yet it is uncertain the extent by which such comprehensive understanding was utilised by decision-makers, likely due to the lack of familiarity and acceptance of such types of approaches.

Community beliefs and perspectives need to be considered when designing adaptation strategies. In their study of

coastal erosion within Denimanu on Yadua Island, Fiji, Martin and colleagues (2018) found that the beliefs that community members held were diverse and led to contested responses, with older members of the community feeling a sense of self-sufficiency in dealing with challenges whereas younger community members sought assistance externally, leading to the authors' assertion that residents' worldviews and beliefs be acknowledged when developing adaptation strategies.

Máñez and colleagues (2012) also advocate for the need to implement island-specific management measures and management undertaken by local institutions, in response to previously sporadic and generic support. Self-help initiatives to address water, sanitation and hygiene challenges in Fiji have successfully been implemented through existing social networks based on kinship and place, aided by cultural norms of obligation and reciprocity (Love et al. 2023). Finally, Cunningham and colleagues (2020) found that improving the connectedness of formal and informal knowledge networks that have been fragmented, in order to better share timely information regarding ongoing threats to water quality, could help address poor health outcomes.

Local context is therefore very significant in terms of planning and implementing strategies, but how is it addressed? Responding to a lack of consensus around an effective framework for guiding climate vulnerability and adaptation assessments for coastal communities, Mcleod and colleagues (2015) have designed one such framework informed by expert knowledge that can aid the identification of local impacts from climate change. This framework also identifies adaptation strategies that are locally relevant by considering social vulnerability and its drivers, as well as the local adaptive capacity to inform management decisions. While its efficacy was not yet tested at the time of publication, this framework was validated through the Delphi technique of assessment from a panel of experts.

Taking up the challenge of developing a locally tailored management plan, in this case for Smith Island of North Andaman, Sridhar and colleagues (2020) identified different areas of the island, identifying both existing and proposed developments, schemes for conservation and preservation, dwelling developments and infrastructure projects. Geographic information, specifically on coral reef, mangrove and seagrass beds, was gathered, and a High Tide Line survey undertaken. This data informed an Integrated Island management plan to ensure that environmental concerns of such islands are considered and proved successful covering a 10-year period.

Klaas and colleagues (2020) developed a set of tailored management strategies for dealing with a deficit of groundwater on Rote Island, Indonesia, from both climate and demographic challenges, including adaptive strategies focusing on socio-cultural, technical, and ecological measures. Comprehensive assessment methods including downscaling of climate variables, groundwater model development and analysis, evaluation of groundwater and atmospheric models, and water demand analysis evaluate and refine proposed management strategies. The authors believe these proposed management strategies are valid and applicable for other karst islands. This limitation highlights the importance of considering topography and geology when evaluating different strategies.

Broaden the options beyond the usual suspects

Choices in climate adaptation are based on the options that are considered. The usual suspects may include things like rainwater harvesting, mangrove plantations, desalination or flood barriers. However, communities usually have options for adapting to adverse conditions beyond what is traditionally acknowledged.

For example, faced with climate-induced dry periods within the Pacific Islands, Pearce and colleagues (2018) identified that local residents of Vusama, Viti Levu in Fiji who were without connection to government water supply, and juxtaposed with neighbouring tourist and golf resorts with plentiful freshwater supply, innovatively turned to short-term adaptation measures including earning extra money, rationing fresh water and relying more on social networks to stave off the worst effects of a freshwater crisis that is threatening their livelihoods, and their physical and mental health. Despite this innovative adaptation by the community, which presumably requires considerable effort and resources, Pearce and colleagues (2018) raise questions around the inequity this water crisis raises, particularly given significant international aid and tourism revenue within Fiji and point to the need for long-term adaptation measures.

Within the Republic of the Marshall Islands, Elliott and colleagues (2017) highlight the importance of considering the variety of water sources households rely upon for climate resilience research and policy. Additionally, they have identified that in response to a lack of surface water and limited groundwater, rainwater has been harvested, conserved and shared with neighbours as a form of community-based adaptation, and acknowledge this community resilience while advocating for the formalised distribution of rainwater tanks for households with the goal of improving their climate resilience.

Karlsson and McLean (2020) identify a variety of ways in which fishers within the Dominican Republic and Belize have employed climate adaptation strategies including conserving and sharing resources, drawing on knowledge and being flexible, and diversifying livelihoods and intensifying fishing; however, they point out that such adaptation strategies are not sufficiently transformative over the long term. They point to the potential that financial support or temporary forms of employment in response to seasonal vulnerability, improving formal credit access and reducing the cost of small loans, could help to strengthen fishers' resilience.

While it is not advantageous to rely upon locally driven adaptation strategies alone, care must be taken when selecting formalised adaptation strategies to implement. As MacDonald and colleagues (2020) highlight in their study of the Republic of the Marshall Islands, some technical solutions can generate further problems through unintended consequences, offering the example of reverse osmosis leading to saltwater intrusion into freshwater lenses due to over pumping, thereby resulting in brackish freshwater lenses that are unsuitable for water supplies.

Account for capacity constraints

Assessing the interlinked challenges of disaster risk, climate change and water security faced by SIDS, Gheuens and colleagues (2019) examine the perceptions and actions taken by SIDS to address disasters; their water security status; and identify the gaps and needs for achieving Sustainable Development Goals, climate adaptation and resilience building. Their findings highlight the importance of addressing climate risk and security through best practice and lessons learned from a combination of effective governance, integrated policies, community resilience and this especially includes capacity building.

Capacity building, for example environmental disaster education, training, knowledge exchange between stakeholders, public awareness programmes and relevant research (Tanavud 2007), is recognised as having the potential to facilitate governance and policy benefits for vulnerable groups with the potential to lessen conflict thereby increasing political stability and is also considered capable of facilitating adaptation to disaster risk, climate change and water security challenges.

Include the exit strategy as an option

Climate change poses severe risks to the habitability of atoll islands, and this risk should be thought of as the cumulation of risks to freshwater supplies, land habitability, food supplies, housing and infrastructure, as well as economic activities (Duvat et al. 2021). In other words, adapting freshwater supplies is only one piece of the puzzle, and under severe climate change scenarios (i.e. RCP 8.5), the habitability of most atoll islands is a very severe risk (Duvat et al. 2021). If resources are not adequate for addressing such risks, then migration needs to be an option to consider. Risks to habitability however also vary significantly between islands (Duvat et al. 2021).

In their study of the Pacific Islands, Mcleod and colleagues (2019) outline the variety of traditional and innovative scientific climate adaptation strategies implemented in this region, and how many of these strategies are being widely implemented at the national level; however, they point out that in some cases these innovations will be insufficient to adequately deal with the climate challenges faced and raise the prospect of the need for migration in these cases. Mcleod and colleagues (2019) therefore call for further research to be undertaken to assess locations and populations most likely to be impacted by adaptation limits. When beyond such adaptation limits, migration is framed by Mcleod and colleagues (2019) as a last resort.

Within the work of Kothari (2014), it is clear that migration is considered contentious among residents of the Maldives as a result of community concern that governments exploit climate challenges as a guise for the motive of achieving economic efficiencies through resettling dispersed populations into centralised areas, in this case bringing a population spread across 200 islands onto between 10 and 15 islands.

In an attempt to better understand the health and quality of life impacts of climate-induced migration for residents of Fiji's low-lying coastal villages over a 5-year period, McMichael and Powell (2021) identified a combination of health benefits including access to drinking water and sanitation, food security and livelihood opportunities, alongside new risks including alcohol and packaged food consumption and disruptions to social structures, traditional values and place connection as a consequence of this last resort.

In response, McMichael and Powell (2021) advocate for context-specific planning with impacted communities to inform decision-making around planned relocation and for such planning to be responsive to the foundations of human health, as well as the social determinants of health. Lawrence and colleagues (2020) predict that migration, or what they term "managed retreat", will become an increasingly unavoidable response to climate challenges and how it can be implemented pre-emptively, rather than in post-disaster contexts, alongside how it can be sequenced, socialised and undertaken through governance enablers for those areas facing ongoing sea level rise. Additionally, they consider challenges of implementation, novel decision-making tools to address the changing nature of risks and the understudied arrangements in this area relating to governance, institutions and funding. In response to climate-induced migration within Pacific Island Countries and Territories, Campbell (2022) suggests that urban areas are most likely to be the only, or least problematic, migrant destinations, not to discount the climate challenges posed within urban areas as previously mentioned such as flooding (see Goh 2019), and long-term habitability challenges within urban atoll islands. As urbanisation progresses rapidly in many SIDS, with an associated rise in informal

settlements and/or increase in vulnerability among urban populations (Weir et al. 2017), Campbell (2022) points to three strategies to help ameliorate resultant urban densification issues including firstly improving urban governance and secondly planning so that migrants have equitable access to available services, securing migrant tenure, and thirdly, leveraging existing knowledge on kinship networks and resilience practices for those migrants who find themselves within informal settlements. Weir et al. (2017) also note that urban populations tend to lack many of the social and traditional structures for decision-making, so, therefore, require different types of involvement from national governments.

Synthesis: five principles for adaptation

The reviewed literature highlights the complexity of climate adaptation in atoll environments in SIDS. This arises from the need to balance sometimes conflicting values (equity, livelihoods and ecology), the need to account for highly variable social dynamics, physical features and capacity constraints, and the need to adopt a systems perspective but without the capacity to rely on experts or extensive data.

Principles for future success

Principle 1: Get the community on board or solutions will fail.

Adapting solutions to local contexts, ensuring community buy-in and drawing on the creative solutions of local communities have all been identified as key recommendations in the reviewed literature. This helps address capacity constraints, better build more suitable sustainable livelihoods and account for interconnected social-ecological values. This consolidates other calls made for community-based adaptation (see Forsyth (2013), McNamara et al. (2020), Vincent (2023), Westoby et al. (2020)).

This finding is perhaps not surprising considering that the societal and cultural norms, as well as the social networks and power relations of island communities, have created functional socio-economic environments that existed long before the need for external intervention. To ignore the existing context or try to manufacture an alternative lived reality for the good of more efficient project management, is inherently flawed, as it goes against the natural flow of local behaviour and process, making the job more difficult and in some cases unfeasible. As such, interventions need to not only understand, but use, the local socio-cultural context to resolve the issue, embedding solutions within the existing social dynamics and, if possible, using available local knowledges and resources to resolve issues. This speaks far less to community engagement, where the community takes an advisory role on project design and implementation, and more to community development, where existing (and potential) human capital becomes the cornerstone of the solution, effectively using existing community resources and capacity to resolve issues. Governance then becomes far less about managing projects than facilitating local governance to manage itself, though with external assistance.

Principle 2: Expand the option space through experimentation.

The importance of learning through adaptive governance mechanisms, systematically building the evidence base for new solutions and thereby carefully adapting solutions to local contexts has been identified as key recommendations in our review. An obvious method for achieving this is to draw on the emerging field of sustainability experimentation (Brundiers and Eakin 2018; Bulkeley and Castán Brotto 2013; Rodima-Taylor 2012; Hölscher et al. 2019; Wolfram 2019), to develop appropriate frameworks for learning and systematically building knowledge over time.

This principle relates to learning and knowledge management, but also to mechanisms for reframing and/or building supporting institutions and community buy-in, which can be challenging topics in low-capacity locations. To overcome this issue, small-scale experimentation, however, allows for testing promising solutions that worked elsewhere. This will somewhat slow down implementation but is likely to lead to better outcomes in the long term. This will allow for greater diffusion of locally adapted innovation and will help overcome the risk of poor designs that are inappropriate for local contexts.

Principle 3: Be serious about monitoring and evaluation using local knowledge

The importance of an evidence-based systems perspective, adaptive governance, breaking down of silos in governance and planning, consideration of equity and fairness, and to be mindful about capacity constraints and local context are all recommendations from the literature. To achieve all this, presumably through participatory means, requires careful navigation and is a highly complex and often time-consuming task (Lynam et al. 2002). A way to support this type of navigation is to monitor and evaluate progress, both in terms of improvements in outcomes, but also in terms of risks and adverse impacts (Islam 2020).

But how can this be achieved in contexts with the limited staffing and financial constraints of SIDS? The answer would appear to lie in the use of community knowledge and feedback, which while potentially imperfect in some respects will provide rapid flows of information that can allow for learning and corrective action (Shukla et al. 2018). This type of feedback mechanism can also help to facilitate the dialogue between locals and external stakeholders (Faulkner et al. 2015).

This principle asks that a monitoring system for evaluating progress be established as part of the project plan to both ensure two-way communication between internal and external groups, as well as to ensure project success and failures, as conceived by both locals and external stakeholders, while acknowledging potentially contradictory visions and interests, are captured to allow the grander programme of work to evolve.

Principle 4: Adopt decision-making mechanisms that are systems-oriented and inclusive

The reviewed literature suggests the importance of adopting a systems perspective, in part because of the need to make trade-offs, but also because of the multifaceted nature of social-ecological problems that have dynamic system features that require careful consideration. This aligns with modern resilience theory (Woodruff et al. 2018; Walker 2019; Mulligan et al. 2016; Forsyth 2018; Fath et al. 2015).

In particular, this relates to the important role of community views, and perceptions of equity and fairness, as well as careful consideration of environmental dynamics thresholds and tipping points (Walker 2019). The complexity of island contexts means that siloed projects, in terms of singularly considered solutions with a single management and monitoring group, are prone to failure. While the totality of the system may never be fully understood except perhaps with hindsight, a holistic approach is required to, at least, map the critical inputs, processes and outputs for each system, so that project implementation can be addressed in terms of feasibility at its design stage. It is also important to recognise the important role of community mental models and perceptions in driving systems behaviour (Jones et al. 2011).

More important, however, is the inclusion of pivot points and flexibility that allows for adaptation while still in implementation, where decision-making can be done in an adaptive way, based on the feedback being provided from a monitoring regime and in line with the community development principles covered above.

Principle 5: Only invest if there is a long-term commitment to the protection of the islands

Climate change poses an ethical dilemma as some research suggests that most atolls will be uninhabitable within only a handful of decades (Storlazzi et al. 2018). To what extent should a large-scale exodus of these islands therefore be considered? The social and cultural value for the community of staying on the islands can hardly be over-estimated, yet on the flip side of this argument, resources to support island communities now could instead be used to provide a longer-term solution. Importantly highlighted by Farbotko and Campbell (2022), conceptions of uninhabitability and habitability informed by cultural, social and historical factors for impacted residents should be considered in decision-making, and beyond the focus on housing, food and water within security studies for example. Ultimately, we believe that long-term solutions can be facilitated on the atolls, if very significant funding is provided, but SIDS are likely to be unable to afford this by themselves, and richer nations may baulk at the cost of doing so. Furthermore, we note that there is contention and uncertainty about this issue, especially as the projections for sea level rise are becoming more severe over time (Rounce et al. 2023). In relation to this, we also note the recent announcement by Australia to allow all residents of Tuvalu the right to resettle in Australia, in clear recognition of the existential threats to these nations from climate change (Dziedzic 2023).

The United Nations predicts that US$300 billion will be needed for the Loss and Damage Fund annually by 2030 for climate adaptation, with current financing for climate adaptation between five to ten times below what is needed (UNEP 2022a, b). If there is a long-term commitment to protecting these islands from the risks to communities of increased sea levels and associated storm surges, then climate adaptation investments will help communities stay in their ancestral lands. However, if there is no such a commitment, then the resources could be better used to support these communities to adapt elsewhere. We also note that, as is evident from previous sections of our article: that projects imposed from outside with inadequate local consultation are doomed to failure, as islanders will not maintain projects that do not have wide support in their community.

Additionally, where sufficient adaptation or migration has not occurred, it will be important to ensure that sufficient legal protections are established. The United Nations Human Rights Committee has provided a ruling

stating that nations will be in breach of their human rights obligations if returning people to countries where people's lives are at risk due to the climate crisis; however, this ruling is not legally binding (UN Human Rights Office 2020). With reference to sea level rise impacting Small Island States, new law is needed to protect these populations from "becoming marginalised and disenfranchised inhabitants of their countries of refuge" (Chaudhary 2022 p.456).

The dilemma of financing climate adaptation efforts

Climate adaptation projects require large-scale funding, as highlighted by the estimates of annual requirements of the Loss Damage Fund (UNEP 2022a, b). Unfortunately, however, climate finance in SIDS is so far very low (UNCTAD 2022). SIDS in general do not have the financial resources to pay for this, even if the moral imperative is present, and climate financing rationales can be made by framing investments around promoting climate-resilient economic growth (Friedman 2023). It should also be noted that, by contributing knowledge, labor, money and ongoing monitoring, local communities do have significant capacity to "help themselves" if given the right tools and opportunities, and this is an opportunity to reduce the cost of adaptation. It has also been found that "many multilateral climate funds have been rife with administrative issues, creating barriers to access for particularly vulnerable countries" (Kalaidjian and Robinson 2022). Funding agencies, and national governments alike, therefore, need to reform and rethink funding mechanisms, so that adaptation can be accessed and implemented with a greater chance of long-term success and we think they should prioritise funding towards projects that align with the principles in this article.

Conclusions

The focus of this paper has been to capture the range of perspectives from recent literature relating to climate adaptation and water management in SIDS, with the aim of informing a best practice for ongoing and proposed climate adaptation funding. Noting decades of institutional inertia, we entered into this review by attempting to understand what shapes the decision-making contexts within which climate adaptation occurs, hoping thereby to find ways to enable more effective action. Specifically, we identified a series of key values, rules and knowledge required for adaptation, specifically values to guide decision-making around equity and fairness, interconnected social-ecological values, and sustainable livelihoods. Rules to guide decision-making focused on adaptive governance, community empowerment and breaking down of silos in planning and governance. Knowledge to support decision-making based on embracing an evidence-based systems perspective, better understanding of place and context, expanding the options space based on experimentation, and accounting for capacity constraints.

In other words, a comprehensive approach that addresses the complexity and multi-faceted nature of climate adaptation is recommended. Additionally, it is important to ensure that sufficient time is provided for the implementation of climate adaptation projects to gain the most benefit from available investments. Adaptation efforts can fall along a continuum from successful adaptation to maladaptation (Reckien et al. 2023). Ensuring that the risk of maladaptation is first assessed prior to implementing initiatives has significant importance (Magnan et al. 2016), and it is interesting to note that one common intervention of building sea walls has been found to be nearly always maladaptive especially at village level (Nunn et al. 2021). The success of future climate adaptation initiatives can be strengthened by responding to local communities drawing on their experiences of past initiatives, as they are best placed to identify proposed adaptation measures that have a greater or lesser likelihood of efficacy. This consolidates the calls put forward by Nunn and Kumar (2018) and by Petzold et al. (2023) who highlight the importance of responding to the distinct cultural contexts in which these efforts are made. To ensure that the available technical solutions for climate adaptation are effective in their response to community needs, community engagement across the whole community is critical. There is tension however, particularly in relation to funding models and the expectation of engineered solutions to be implemented immediately. If projects do adhere to these recommendations, it will see more time and budget going towards planning and administration aspects of projects, including monitoring, evaluation and adjustment as required, before immediate gain can be illustrated. While this may require greater expectation management from funding organisations, and potentially longer funding timelines, we would argue that, if these recommendations are not followed, the result will be engineered solutions, implemented on time and on budget but which, due to a lack of engagement and governance diligence, risk going unused and ultimately fail.

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