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A habitability lens to boost effective local climate adaptation

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ABSTRACT

Climate adaptation is what we (will) make of it, that is, either a burden or an opportunity for a brighter and equitable future. Achieving effective adaptation requires shifting from a risk-centric perspective focusing on the threats, to a more inclusive and engaging approach that envisions sustainable futures. This Perspective draws on our decades of research experience to argue that the "habitability" lens can catalyse this shift, and proposes a research framework.

1. Introduction

Humankind has a long history of managing weather-related hazards (storms, landslips, wildfires, droughts, etc.) through practical interventions, trial and error, cosmogonies and, more recently, scientific and institutional processes. Climate change now challenges contemporary societies to build on this experience to anticipate accelerating changes in fundamental environmental conditions (e.g., sea level, permafrost, water resources) and extreme events. Climate adaptation science explores this issue, with both encouraging and gloomy conclusions. On one hand, approaches and tools exist to support long-term, flexible planning under high uncertainty, making the case that some leeway for action remains even under high global warming projections (Stroombergen and Lawrence, 2022; Haasnoot et al., 2024). On the other hand, additional severe climate risks are expected at lower levels of global warming than previously thought (Zommers et al., 2020; O'Neill et al., 2022; Marbaix et al., 2025); various communities and ecosystems are approaching adaptation limits (Thomas et al., 2021; O'Neill et al., 2022); and the range of available adaptation options is at risk of shrinking with warming (Haasnoot et al., 2021). It is also evident that hasty responses can result in maladaptation (Nunn et al., 2021; Reckien et al., 2023; Schipper and Mukherji, 2024); current interventions often fail to account for cascading and compounding climate risks (O'Neill et al., 2022; Anisimov et al., 2023); and stakeholders remain insufficiently engaged in adaptation (Petzold et al., 2023; Wannewitz et al., 2024). As a result, despite advances in planning approaches to reduce climate risks, we are not yet on track to achieve ambitious adaptation globally (Magnan et al., 2023a; UNEP, 2024).

In particular, the gloomy conclusions above can discourage more radical adaptation (Morrison et al., 2022; O'Neill, 2023). There is, therefore, growing impetus to shift from a perceived negative risk-centric approach focused on what threatens us, towards a more inclusive one that envisions desirable or at least acceptable futures and achievable pathways. Here, we argue that a focus on habitability (Box 1) offers a way to operationalise this shift because it makes locally acceptable outcomes a starting point for action. We outline this

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hypothesis, present a habitability-driven research framework, and conclude with a caveat.

2. The hypothesis: reframing adaptation from "what we will lose" to "what we want to keep and improve" can bring substantial benefits

2.1. A three-fold rationale

This section presents three arguments for reframing adaptation that are draw from our decades of research experience in climate risk and adaptation in atolls.

First, because catastrophes triggered by high-intensity extreme events are still perceived as anomalies rather than the new norm, they seldom prompt societies to shift from short-term reactive to long-term anticipatory responses. This results in a gap in moving from conventional interventions, which are simply not fast nor deep enough to build climate resilience, to radical ones that truly address 'the underlying root drivers of a problem rather than its proximate causes and symptomatic effects' (Morrison et al., 2022, p. 1100). This in turn leads to entrenching historically rooted drivers of exposure and vulnerability, such as the ones leading poor and landless people to dwell in flood-prone places in the vicinity of urban areas (Duvat et al., 2013, 2017; Fawcett et al., 2017; Lazarus, 2021), and reinforcing path-dependencies and adverse outcomes (Oppenheimer et al., 2019). There is considerable evidence of this across latitudes and development contexts, from the Arctic (e.g., Ford et al., 2015; Constable et al., 2022), to temperate regions (e.g. in the USA in the aftermath of hurricane Katrina: Burby, 2006; Laska, 2008) and tropical small islands (e.g., Duvat et al., 2017; Magnan and Duvat, 2018). This observation questions the relevance of using climate impacts and risks as a basis for achieving effective adaptation, and calls for shifting towards a more inspiring narrative.

Second, while governing institutions are essential for setting shared priorities, facilitating large-scale processes as well as planning and funding adaptation (Engbersen et al., 2024; UNEP, 2024), a recent systematic review suggests that at the micro level, individuals and households are the primary implementers of adaptation measures, most of which are driven by autonomous actions (Petzold et al., 2023). In line with the Locally Led Adaptation approach that prioritises the lived realities and needs of the communities most directly affected by climate change (Feisal Rahman et al., 2023), this suggests that the perspectives of resident communities must be integrated more comprehensively into local adaptation strategies. Indeed, while formal institutional processes are key to enabling action and ensuring consistency across localities within a same jurisdictional entity, for example, through risk reduction regulations, they do not automatically generate knock-on effects at the local level. Thus, when it comes to effective local adaptation, shifting away from a dominant top-down institutional approach is expected to be more empowering and suitable for leveraging community strengths and catalysing solutions that align with local aspirations (Oliver et al., 2023; Farbotko et al., 2023; Mills-Novoa and Mikulewicz, 2024). Such a shift, however, requires making the adaptation challenge more appealing to people – something that the "what we want to keep and improve" angle is expected to help achieve.

Third, the fact that people are engaged with behavioural and cultural responses (Berrang-Ford et al., 2021; Petzold et al., 2023) highlights the central role of values and psychological processes such as attachment to place and emotions, for example, in both driving more effective climate adaptation and generating stronger political support (Harth, 2021; Nightingale et al., 2022; Ojala, 2023). Although pessimistic scenarios can translate into behavioural changes in some cases (Morris et al., 2020; Blythe et al., 2021), our research experience suggests that shifting from a risk-centric to a habitability-centric perspective increases the potential for putting positive emotional and relational dimensions at the forefront of adaptation debate and action (Harth, 2021).

2.2. Galvanize action

Robust evidence from behavioural science indicates that hope is more effective than fear in encouraging climate action (Schneider et al., 2021; Mortreux et al., 2025) and that emotional commitment to shared human relations is key to driving change (Nightingale et al., 2022). Such insights call for a new framing for climate adaptation that connects more effectively at the individual and community levels. We argue that a desirable future habitability perspective can support such a new framing.

In oceanic and atoll islands, for example, climate change impacts are usually framed around the imminent loss of land, i.e., uninhabitability. In this context, "what we will lose" shapes the adaptation narrative primarily around the deterministic, inevitable and anxiety-provoking faraway relocation of people. For atoll islands especially, the climate urgency discourse of the 1990s and 2000s put forward the idea that their populations should be relocated to distant higher islands or foreign countries. Some studies, however, show that local relocation can be an alternative to support future, desirable habitability (Kench et al., 2018; Duvat et al., 2022). In Rangiroa Atoll, French Polynesia, for example, safer, more elevated areas exist within the atoll rim, where inhabitants have land rights and strong ties to place and where they usually prefer to move rather than relocate far away (Duvat et al., 2022).

This example, one of many, illustrates the needed shift from a defeatist attitude ("the atoll will become uninhabitable") to a proactive one ("there are still options available to maintain future habitability

Box 1
Defining habitability in the context of climate change.

The IPCC adopts a biophysical, western perspective to define habitability as 'the ability of a place to support human life by providing protection from hazards that challenge human survival, and by assuring adequate space, food and safe freshwater' (Möller et al., 2022), hence fostering economic opportunities, livelihoods, human health and societal well-being (Bennett et al., 2019; Horton et al., 2021; Spencer et al., 2024). Habitability, however, is far more than that: 'the qualities that make a particular place acceptable to live in are culturally and historically specific, involving local [and Indigenous] knowledge, cosmogonies and place attachments' (Farbotko and Campbell, 2022, p. 186; see also Sterly et al., 2025). There is also a very personal dimension to assessing the liveability of a place *[N.B.: this paper focuses on the community level]*. Habitability, therefore, depends on both tangible and intangible factors, with context-specific adaptation shaped by varying levels of risk tolerance.

Two key questions that are still unresolved are: how can habitability be assessed in a comprehensive way (bringing various habitability pillars together)? And how can desirable habitability be connected to the climate adaptation challenge? To answer these questions requires developing a habitability-for-adaptation research framework.

within the atoll"). The former attitude creates a sense of victimhood, whereas the latter clearly holds more promise for engaging communities in collective decision-making and minimising resistance to climate adaptation (Mills-Novoa and Mikulewicz, 2024). The latter attitude also resonates with the slogan of the youth group Pacific Climate Warriors: "We're not drowning, we're fighting".

Despite counter-examples, such as in the USA after hurricane Sandy (Rosenzweig and Solecki, 2014; Solecki et al., 2025), our collective, multi-decadal field experience in assessing climate risks and adaptation options and supporting decision-making in the Arctic (Canada, Greenland), the Pacific (Fiji, French Polynesia, Kiribati, Tokelau, Tonga, Tuvalu and Vanuatu) and the Indian Ocean (Maldives, Mauritius Island, Reunion Island, Saint-Martin) confirms that discussing uninhabitability with communities often leads to a conversational dead end, whereas exploring options for maintaining and developing habitability conditions without any loss of attachment to place opens up more productive dialogues. Moreover, the inevitable uninhabitability narrative 'insidiously undermines the permanent sovereignty of peoples over their natural resources [and their right] to self-determination' (Farbotko et al., 2023, p. 751). It can also divert attention away from addressing key underlying risk drivers, such as the settlement of naturally at-risk areas, and bias towards silver-bullet technological solutions (e.g., building floating islands) rather than the hard, patient work of *in situ* adaptation.

The habitability-centric approach aims at reframing climate risks from being burdens to becoming catalysts (Solecki et al., 2025) for creating desirable, self-determined (Farbotko et al., 2023) and more engaging adaptation narratives. This approach in no way downplays the severity of climate risks to habitability nor suggests that *in situ* adaptation will always be possible. Rather, it aims to bring together local/-Indigenous knowledge and scientific perspectives to ask: what do people want for their future? Which levels of climate-related impacts and risks do they consider tolerable, or at least manageable? What adaptation options are available that are both socially acceptable and expected to reduce climate risk? How to sequence such options over time to develop relevant adaptation pathways? Are such pathways feasible in terms of their implementation? And will they be enough to ensure long-term habitability under climate change? Such cascading questions lay foundations for a research framework on habitability to support more locally driven effective climate adaptation.

3. The proposal: a blueprint for "habitability" to enable effective adaptation

3.1. Habitability model

This work builds upon recent endeavours on atoll islands (Duvat et al., 2021; Farbotko and Campbell, 2022) and coastal socio-ecological systems (e.g., Kanan and Giupponi, 2024; Spencer et al., 2024) to identify six main habitability pillars especially relevant in atoll contexts: safe land, safe and adequate freshwater supply, safe food supply, secure settlements and infrastructure, flourishing socio-cultural values and assets, and thriving economic activities. Fig. 1 outlines this model and the endogenous (e.g., local human disturbances) and exogenous (e.g., climate change and globalisation) pressures on the system. The model acknowledges other important dimensions, including terrestrial and marine ecosystems, governance structures and arrangements, human agency and human health, as either underlying drivers of vulnerability and adaptation, or impact areas, but not as habitability pillars *per se*.

3.2. A research framework

We propose a five-step habitability-centric research framework (Fig. 2) to bring together local/Indigenous and scientific knowledge systems, along with institutional processes, with the aim of co-designing long-term climate adaptation pathways, exploring the feasibility of implementing them, and informing the related adaptation limits. This

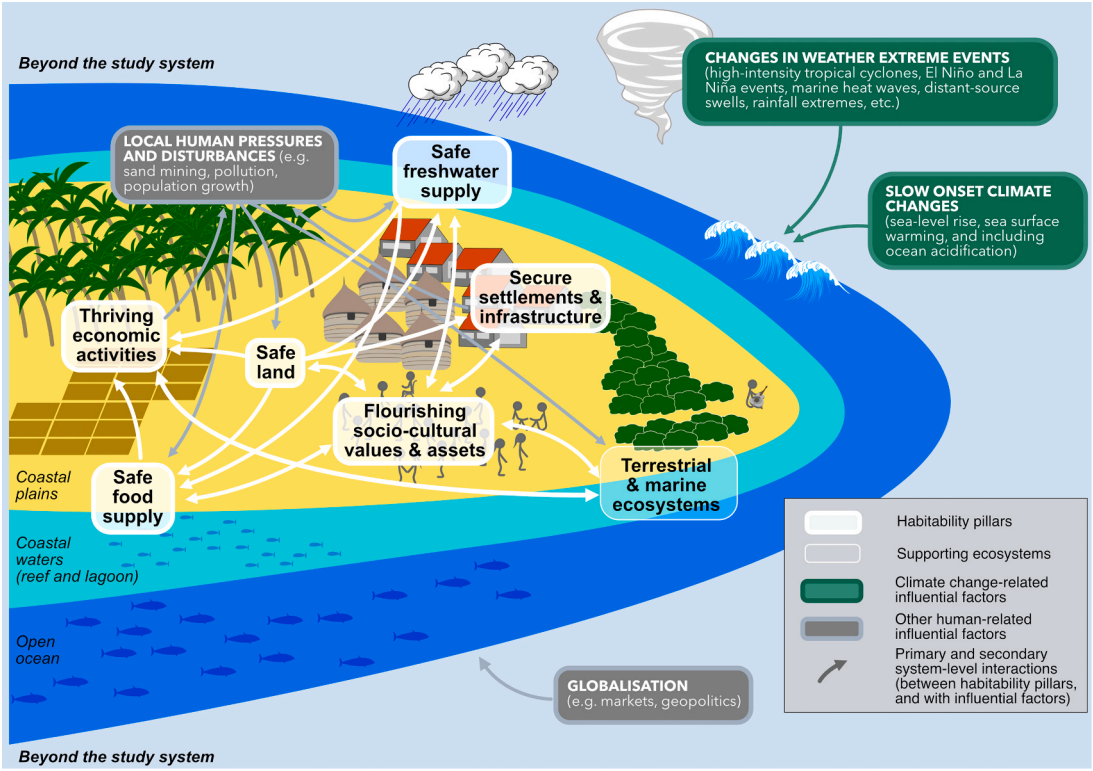

Fig. 1. A conceptual framework for habitability under climate change, using the example of atoll islands; based on Duvat et al. (2021) and Farbotko and Campbell (2022). Arrows illustrate some but not all feedback loops between the habitability pillars. Other external, non-climate shocks, such as pandemics or economic crises, can also influence local habitability but are not represented here.

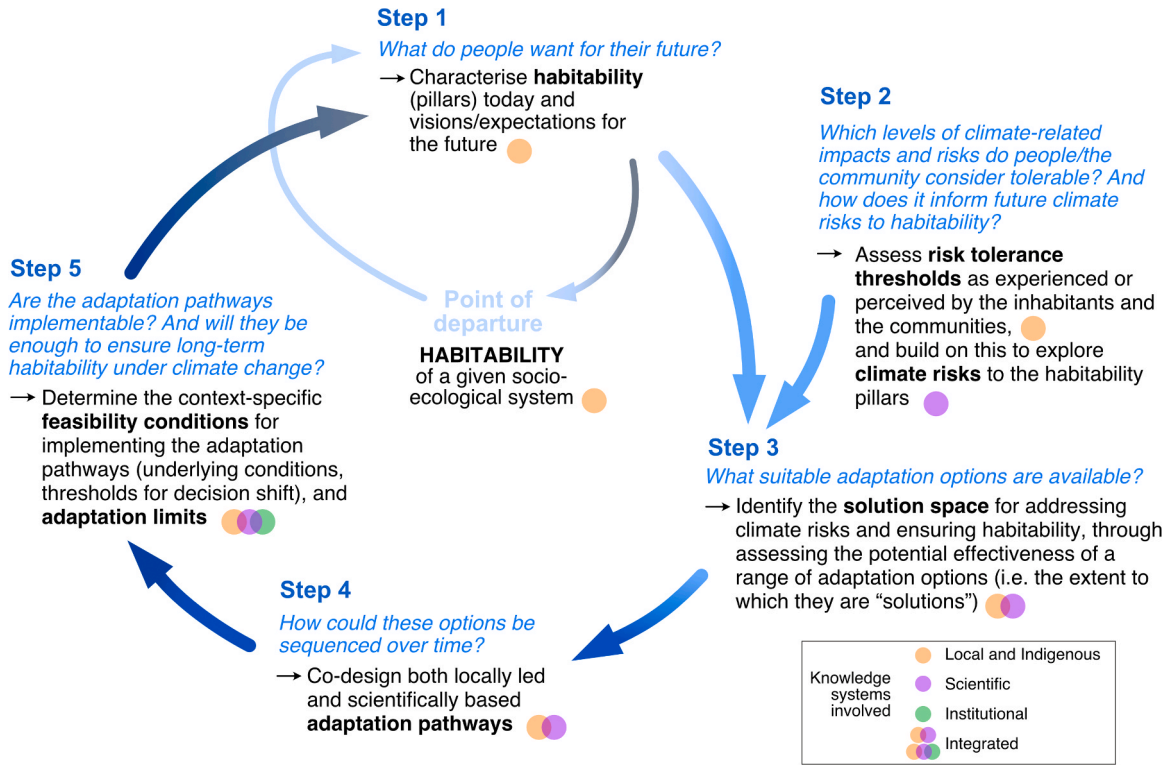

Fig. 2. The overarching narrative of the proposed research framework. The light-to-dark blue gradient of the arrows illustrates the learning process throughout the research steps.

framework is not intended to be prescriptive. On the contrary, it leaves plenty of scope for researchers to decide how to investigate the five steps, given that different contexts may call for specific methodologies. However, ensuring that case studies converge around a common framework will facilitate the sharing of experiences, both within the scientific community and among local communities.

Step 1 characterises current habitability pillars and envisions the future – Assessing the current state of the habitability pillars is a necessary starting point. Based primarily on local/Indigenous preferences, values and worldviews, Step 1 uncovers the essential material and immaterial elements that communities wish to preserve and improve for future generations.

Step 2 identifies risk tolerance thresholds to understand climate risks to habitability – It is only based on the locally led narrative emphasised in Step 1 that climate risks can be introduced. Step 2 especially refers to understanding the context-specific impact thresholds that make risks problematic or even intolerable for people (Dow et al., 2013), to then identify the impact levels that are manageable, though with serious consequences, and those that are simply unmanageable or unacceptable. Alongside with this, Step 2 explores the root causes of climate exposure and vulnerability to understand risk trends as well as the drivers of risk thresholds. Step 2 can be operationalised through field surveys and interviews to collect the local inhabitants' and stakeholders' views on the cascading consequences of past events (e.g., a cyclone), limits to the responses they implemented, barriers that prevented implementation of more efficient solutions and, although often difficult to imagine, future risk thresholds. Such knowledge can then serve as a basis for scientific investigations to assess the implications of future climate conditions on the habitability pillars (see, for example, Barnett et al., 2014; Duvat et al., 2021).

Step 3 identifies the solution space for ensuring habitability – It includes evaluating the future potential effectiveness of a range of adaptation options to minimise climate risk to each habitability pillar. This process helps to differentiate between long-term effective action and short-sighted fixes. Structured Expert Judgment (SEJ) methods offer practical approaches for doing this (Mach et al., 2017; Horton et al., 2021; Majszak and Jebeile, 2023; Magnan, 2023b), with experts being both local/Indigenous people and practitioners, and natural and social scientists. As an example, an SEJ exercise could involve scoring a range of adaptation options against several criteria, under contrasting warming scenarios (e.g., +2°C vs +4°C) and adaptation scenarios (low vs. high), and across different time periods (today, mid- and end-century). Four main assessment criteria could be considered (Fig. 3): i) potential of the option to reduce risks to a given habitability pillar (from low to high; *how much risk reduction to expect?*); ii) readiness for implementation (from initial testing, to real-world pilot studies, to full-scale deployment; *is the option already available?*); iii) lead time to achieve full benefits (from months to decades; *how long will it take to experience substantial benefits?*); and iv) duration of the benefits (from short- to long-term; *how long will the benefits last?*).

In practice, scientists and local/Indigenous people will need to come together in (series of) workshops to discuss how best to apply the four criteria to each adaptation option by drawing on their knowledge, whether gained from scientific research or their own experience of past adaptation responses as well as their perception of future conditions. A range of participatory methods can be used to do this (e.g., Hill et al., 2020; Bohensky et al., 2024), with localised hazard/risk information and mapping that can prove very useful in guiding discussions. Fundamentally, relying on a scoring system offers a way to put the knowledge of local/Indigenous people on the same level as that of (local and external) scientists.

Step 4 co-designs adaptation pathways that are both locally led and scientifically based – As illustrated in Fig. 3, adaptation options need to be positioned along a timescale, depending on their evolving potential effectiveness, before the most promising adaption pathways can be identified. By building on local/Indigenous perspectives on habitability (Step 1), the resulting adaptation pathways are more likely to reflect local priorities, needs and cultural realities, and to be appropriated and

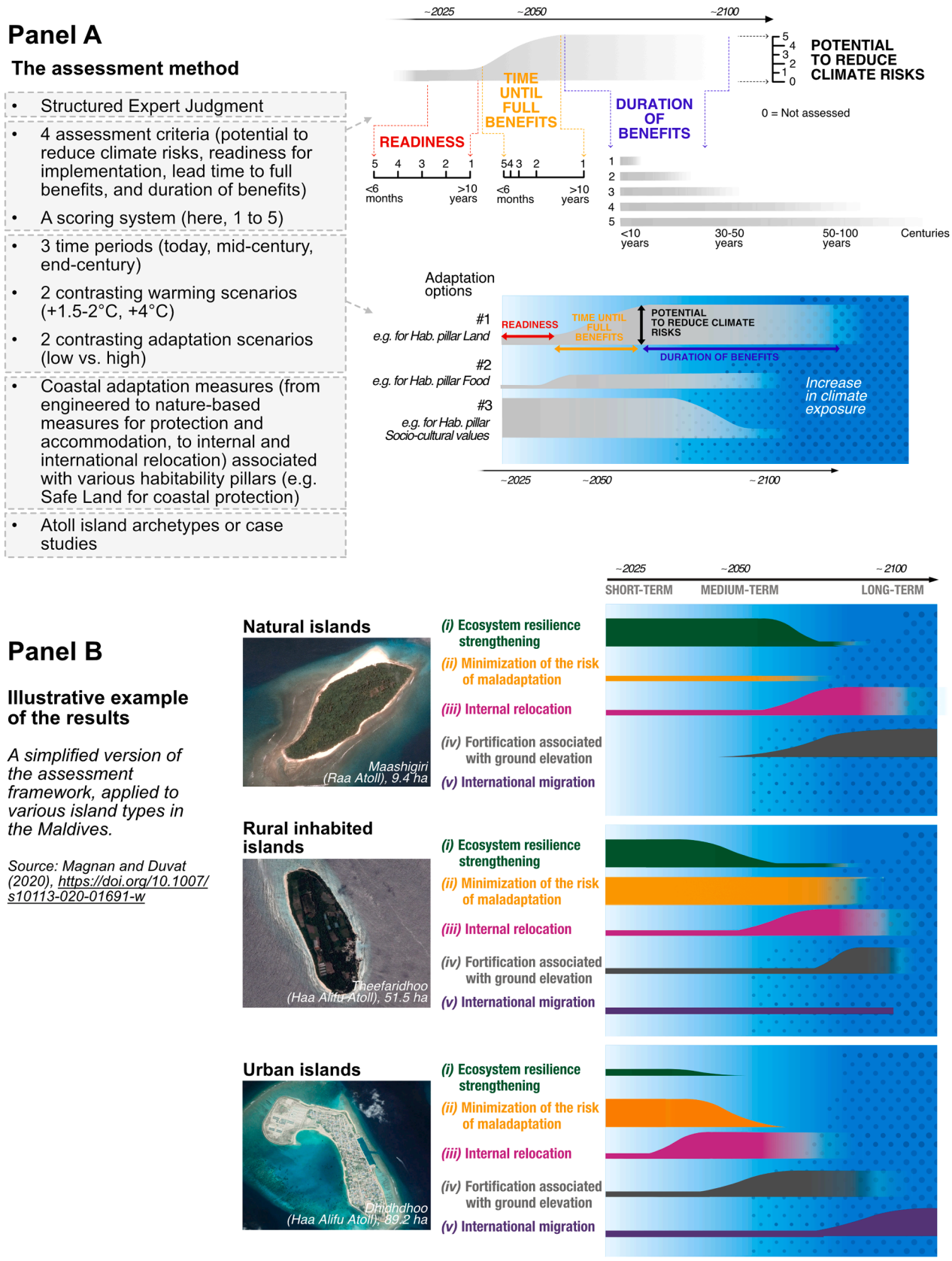

Fig. 3. Example of applying the four main assessment criteria to optimise future habitability of atoll islands. Panel A summarises the assessment criteria and method. Panel B provides an illustration of potential expected outputs, i.e., different adaptation pathways for different atoll island types.

implemented successfully over time.

Step 5 explores the context-specific feasibility conditions of implementing adaptation pathways –Feasibility can be defined as 'the degree to which climate goals and response options are considered possible and/or desirable' (Singh et al., 2020, p. 258) and refers to multiple dimensions going from sociocultural acceptability to physical and environmental constraints, economic and technical opportunities, and institutional capacities to drive change. In our context, these dimensions can be explored by continuing to bring together local/Indigenous and scientific experts to analyse a range of context-specific underlying conditions encompassing, including community-level acceptability, land-tenure processes, socioeconomic leeway, ecological health, governance structures and political will, and financial and technological barriers (Brown et al., 2017; Ratter et al., 2019; Singh et al., 2020). While Step 2 identifies the climate risk-related thresholds at which local decision-making may shift from one adaptation option to another, Step 5 focuses on either preventing such thresholds from occurring or managing their consequences. As such, Step 5 helps inform the nature and dynamics of adaptation limits with grounded evidence, which remains a challenge at the science-policy interface (Berkhout and Dow, 2022; Juhola et al., 2024).

4. Brief conclusion

The proposed research framework calls for a deep involvement of local communities and Indigenous rights-holders in a structured scientific process aimed at strengthening the effectiveness of local adaptation strategies driven by desirable futures rather than the fear of uninhabitability. SEJ methods should be decisive tools within the framework because using scoring systems/scales to create a common language across people, values, data and disciplines (Majszak and Jebeile, 2023; Magnan, 2023b) helps bring together different worldviews and knowledge systems (Ford et al., 2025), which often vary from scientists relying on factual data and local/Indigenous people relying on their own experience of responding to climate-related hazards. Yet, as the literature suggests, defining future habitability under climate change relies on both views. SEJ methods also help address the limitations of other approaches, especially quantitative modelling (e.g., Integrated Assessment Models) and purely qualitative social science approaches (e.g., semi-structured interviews) by, respectively, incorporating more granularity, and enhancing comparative findings across case studies.

The habitability-centric lens should not be taken as a panacea, however. It does not eliminate the need to address structural barriers to adaptation, such as inequity, marginalisation, power imbalance, competing interests, climate and societal uncertainty, institutional latency, and funding gaps. Nevertheless, this lens encourages examination of these barriers from a more proactive perspective, which has the potential to galvanise locally driven processes and result in more effective adaptation on shorter timeframes and, ultimately, on a wider scale.

Author contributions

A.K.M. designed the study, based on earlier contributions from V.K. E.D, J.D.B., J.B., S.D.D., F.D.F., A.M., P.D.N., C.P., T.S.S., C.C.C.W., and I.W. The first draft has been drafted by A.KM. and all authors contributed to several rounds of revision. A.K.M. designed the figures.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

No data was used for the research described in the article.

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