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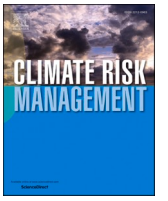

Adaptation-stories for imagining futures adjusting to a changing climate

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ABSTRACT

Effective adaptation planning requires the integration of diverse forms of knowledge – from local experiences to scientific understanding of projections of climate and societal change and their potential impacts on livelihoods and natural systems. However, the volume, complexity and uncertainty of information can hinder stakeholders from taking decisive action. In this study we present a bottom-up approach for developing adaptation-stories that combine quantitative estimates with qualitative knowledge and experience for portraying past or "imagining" future climate change impacts and adaptation responses. The approach is based on a participatory process comprising five steps: (1) co-definition of a notable climate change impact affecting a chosen livelihood or other specific context; (2) identification of the specific types of climatic and non-climatic factors responsible for the given notable climate change impact; (3) co-evaluation of adaptation measures for ameliorating or exploiting impacts, (4) characterisation of the causal mechanisms and assumptions that specify how the notable impacts and their adaptation have been experienced in the past and how they may develop in the future; and; (5) co-development of adaptation-stories by researchers and stakeholders. We suggest that well-crafted adaptation-stories may empower local actors by exploring climate change adaptation through the lens of their unique experiences and livelihoods. They can also serve as conversation starters between diverse actors and generally spark thinking about adaptation solutions. We illustrate this through a case relating to the planning of a major renewal of a hospital in Finland, reflecting how different actors have adapted to heat-related challenges.

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1. Introduction

Stories and storylines have long been used as scenario communication tools that assist inunderstanding environmental changes and facilitate thinking about means to ameliorate their adverse effects (e.g., Kearney, 1994; Alcamo et al., 2001; Rounsevell and Metzger, 2010; Moezzi et al., 2017). A narrative form of description certainly makes it easier to comprehend complex future developments captured in the global scenarios typically employed in climate change analysis. The use of narrative storylines for this purpose was pioneered by the Intergovernmental Panel on Climate Change (IPCC) in its Special Report on Emissions Scenarios (SRES – IPCC, 2000). Narratives are also a key component of the global shared socioeconomic pathways (SSPs) that superseded the SRES (Moss et al., 2010; Riahi et al., 2017; O'Neill et al., 2017, 2020). However, whilst having the advantage of providing worldwide consistency in representations of the future, global scenarios can be ungainly tools for addressing regional and local-scale impacts and adaptation.

Technical methods of downscaling can be used to obtain some quantitative variables at regional scales (e.g., van Vuuren et al., 2010; e.g., Ekström et al., 2015; Terama et al., 2019) for use in impact and adaptation modelling (e.g. Frieler et al., 2017; Holman et al., 2019). Socioeconomic context can also be provided using regional interpretations of global narratives. For SSPs such elaborations are referred to as *extensions* (O'Neill et al., 2014), examples of which have been reported at regional (e.g. Kok et al., 2019; Zandersen et al., 2019), national (e.g. Frame et al., 2018; Lehtonen et al., 2021; Pedde et al., 2021) and sub-national (e.g. Absar and Preston, 2015; Kebede et al., 2018) scales, and see review by Pedde et al. (2025). All of these involve participatory elements that recognise the vital role of local experts and stakeholders for promoting salience, credibility and legitimacy of interpretations (e.g. Alcamo et al., 2001; Rounsevell and Metzger, 2010). More recent studies have begun to combine exploratory scenarios such as SSPs with normative scenarios (e.g. Iwaniec et al., 2020; Frantzeskaki et al., 2019; Pelling et al., 2023).

However, even with such scenario structures in place, quantitative models are limited in the scope of impacts and adaptations that can be represented. They seldom address the most relevant concerns, perspectives, and experiences of a range of different local stakeholders. In these cases, other means must be sought to inform decisions. A narrative approach offers an alternative or complement to impact models. This can help address many of these issues by crafting stories, which use scientific information that is grounded in the lived experience of local frontline practitioners and stakeholders. Here we present an approach for co-creating *climate change adaptation-stories* that combines quantitative estimates with qualitative knowledge and experience for "imagining" future impacts and adaptation options. We argue that carefully constructed adaptation-stories may empower local actors by exploring adaptation through the lens of their unique perspectives and livelihoods, serving to initiate conversations among diverse actors and, more broadly, to stimulate their engagement with adaptation solutions. While our primary focus is on imaginaries of future adaptation (Olazabal et al., 2024a), the approach is also applicable for exemplifying past adaptation.

Though conceived independently, the concept draws inspiration from a set of videos illustrating experiences of adaptive measures already in place or in progress. These were developed by the Australian State of Victoria, and similarly labelled Climate Change Adaptation Stories,[2] to support adaptation in its legislated five-yearly Climate Change Strategy (e.g., State Government of Victoria, 2022). The label "adaptation story" is also applied to illustrative accounts of ongoing adaptation that can be found on the weADAPT platform,[3] in connection with the Adaptation Fund[4] and in the EU's Climate-ADAPT platform.[5] However, we are not aware of this terminology being applied to a formalised method of story development.

The objective of this paper is to propose a general approach for co-creating climate change adaptation-stories. Section 2 presents the rationale for "storytelling" in the context of local adaptation and Section 3 defines the key analytical and co-creation elements of an adaptation-story, linking these into a general framework and steps of analysis. In Section 4 we illustrate the approach by following steps in constructing adaptation-stories to inform the renewal plans for a hospital. Reflections on the effectiveness and broader operationalisation of the approach are discussed in Section 5 before concluding with some key messages and future research needs in Section 6.

2. Storytelling as a communication device to aid adaptation planning

The value of stories as a means of making sense of the world, transferring information and engaging audiences is well-known, from early childhood stories and folktales to storytelling as applied in research. While concerns about the earlier use of stories in science communication may have hinted at a perceived association with fantasy and pretending (Kearney, 1994), more recent concerns are directed towards the need for scientists to become better storytellers (Harris, 2020; Jones and Peterson, 2017; Veland et al., 2018) for supporting social change, so that the world would "change with us, rather than against us" (Bloomfield and Manktelow, 2021). The adaptation-stories introduced here are set primarily in the future, but whilst most accounts may be fictional, none are fantasy, being informed by science, practice and plausibility.

2.1. Approaches to constructing stories

In the field of climate change research, reference to stories, storylines, narratives and scenarios are often made with varying

[2] https://www.climatechange.vic.gov.au/supporting-local-action-on-climate-change/adaptation-stories.
[3] https://www.weadapt.org/how-do-i-create-an-adaptation-story.
[4] https://www.adaptation-fund.org/material/.
[5] https://climate-adapt.eea.europa.eu/en/mission/solutions/mission-stories.

definitions and approaches attached to the terms. We understand"story" similarly as described in Janda and Topouzi (2015) as another form of rhetoric that, like scenarios, aims to help shape the understanding, engagement and expectations of a wide array of audiences, from the public to policy-makers and the scientific community. Like a lens, stories shape data interpretation by highlighting some facts while backgrounding others. Procedures for constructing stories may vary, but all involve a stakeholder-oriented approach, which is central to the construction of adaptation-stories as defined in this paper.

For instance, the widely used stakeholder-driven Story and Simulation approach (SAS) combines qualitative narratives with quantitative modelling to develop environmental scenarios, especially in the global context (Alcamo et al., 2001). While sharing similarities with adaptation-stories, SAS uses storyline format to describe how key drivers, step-wise changes and events unfold in the future, with models providing numerical estimates of selected environmental indicators (Alcamo et al., 2001).

There has been much recent attention on physical climate storylines as a device for the distillation of climate information (e.g., Shepherd et al., 2018; Doblas-Reyes et al., 2021; Baulenas et al., 2023; van den Hurk et al., 2023; Baldissera Pacchetti et al., 2024). However, to inform practical adaptation planning a shift in focus is required. In describing lessons learnt from developing so-called Climate Risk Narratives, Jack et al. (2020) illustrate nicely the transition from a physical climate storyline-type paradigm towards an impact and adaptation orientated mindset. Focusing from the outset on the potential impacts of climate change considered most relevant to the local context, narratives evolved from a means of improving climate science communication to an instrument fostering deep engagement with stakeholders and decision-makers.

Jones and Anderson Crow (2017) outlined a five-step approach for crafting more meaningful climate change stories, drawing on the Narrative Policy Framework (NPF), used in examining how narratives can influence policy-making (Shanahan et al., 2018). The steps include: (1) writing a story using narrative form; (2) identifying the audience and defining the problem based on their preferences; (3) casting characters, focusing on heroes to motivate behaviour change and present viable solutions that evoke positive emotions; (4) plotting elements to connect characters temporally to their environment, focusing on human agency, possible risks and their severity and causality; (5) articulating the moral of the story by focusing on actionable solutions. The approach aims to produce compelling, science-based stories that support the policy process.

Among the advantages of using stories in climate change research is how they allow researchers to work differently, using different methods of inquiry and types of evidence, providing a different perspective, facilitating change in who speaks, gets heard and hears. While someone outside the research community may not speak like a scientist, their insights can be every bit as useful (Moezzi et al., 2017). Regardless of the chosen approach, listening is a prerequisite. For telling and delivering a story successfully the teller needs to be engaged with the intended audience before, during and after the story is told (Harris, 2020). Indeed, the term storylistening has been coined for "the theory and practice of gathering narrative evidence to inform decision-making, especially in relation to public reasoning" (Dillon and Craig, 2021).

2.2. *Stories addressing climate change adaptation*

The potential value of using storylines as a tool to facilitate community-based adaptation to climate change health risks has been explored by Ebi and Semenza (2008). Stakeholder engagement was seen as elemental in the design, implementation and monitoring of interventions. The benefit of narrative approaches was manifested in how they help stakeholders visualise possible impacts, risks and vulnerabilities across a wide array of aspects of community life, hence informing the adaptive responses that might be required. The approach can offer much more constructive assistance than simply providing statements that describe, for example, likely increases in the length of heatwaves.

In addressing climate change adaptation, the drivers and barriers affecting the implementation of adaptation decisions are strongly linked to a range of interacting and contextual societal and environmental factors (e.g. Adger et al., 2005). Ideally, decisions should account for diverse knowledge and viewpoints, and narrative approaches are often seen as a valuable device for capturing these. However, the frame in which stories are told and the context in which adaptation is set can be highly influential in determining how adaptation is practiced and understood, how risks and opportunities are defined, who is authorised to take part in the decision-making process, and the range of adaptation options considered.

New conceptualisations are needed that expand imaginaries and visions of what adaptation can and cannot be (Olazabal et al., 2024a). How stories about past experiences and actions are told in a community may ultimately determine how the community

Table 1
Characteristics of an effective story and how each aims to aid understanding of information.

Characteristic	Aim
Action-based conceptualisation[a]	Promote social learning, agency and, hence, action in real life
Certainty language[b]	Aid assimilation of knowledge
Concreteness[c]	Pave the way for a reader's imagination to aid understanding
Human scale[c]	Facilitate manageable treatment of global scale issues
Interesting content[c]	Catch a reader's attention so they may leave with useful knowledge
Positive messaging[d]	Promote proactive and constructive action
Present tense[e]	Avoid future discounting
Relatedness[c]	Allow new information to resonate with existing beliefs and relate to daily experiences
Truth (vs fact)[f]	Encourage an understanding of truth via one's own imagination rather than through acceptance of received facts

[a] Meyer et al. (2020); [b]Budescu et al. (2014); [c]Kearney (1994); [d]O'Neill & Nicholson-Cole (2009); [e] Hill et al. (2008); [f]Harris (2020).

understands and practices future adaptation (Paschen and Ison, 2014). It has also been suggested that careful attention to narrative may even be key to moving away from a pure natural science basis for decisions and into practical adaptation (Veland et al., 2018).

The use of normative visioning techniques in a participatory setting is increasingly being advocated as a means to assist stakeholders in imagining desired futures in a changing climate (e.g., Frantzeskaki et al., 2019; Pelling et al., 2023). Using urban planning examples, Normative Future Visioning (NFV) processes have been proposed as a necessary component of inclusive climate change adaptation (Pelling et al., 2023), typically combined with exploratory scenarios into hybrid forms that balance desirability with plausibility (Comelli et al., 2024; and see Iwaniec et al., 2020). Such exercises, designed to support regional decision making, have been shown to result in improved climate literacy and an enhanced impetus for inclusive and equitable adaptation action (Nalau and Cobb, 2022). There could be advantages of embedding adaptation-stories as illustrations of specific adaptation cases and perspectives within the context of such future visioning exercises.

2.3. Characteristics of an effective story

Table 1 summarises some characteristics of an effective story that have been reported, and which are elaborated further in this section. Overall, to facilitate learning from text, it ought to be structured in a way that takes advantage of cognitive processes and is integrated with the reader's "real-world" knowledge (Kearney, 1994).

A concept that stands out in this context is that of imagination. It contrasts with the communication practice of relying solely on rigorous scientific evidence, often termed the knowledge deficit model. The latter, while offering benefits of factual rigour, is also acknowledged as frequently falling short in its ability to persuade (Jones and Anderson Crow, 2017). It is the diversity of narrative forms, from scientific articles to fictional writing, that together have a role to play in setting the conditions for imagined and possible futures. These narratives also help address climate change challenges that cannot be solved through prescriptive approaches (Veland et al., 2018). For a story to evoke imagination, its *concreteness* in relation to the listener's lived experiences is directly associated with the ease with which a mental image can be formed. Together with *interesting content* that is supported by coherent and vivid detail conditions are created for the reader's imagination to aid understanding of the information (Kearney, 1994).

Also important is the *relatedness* of the new information to the reader's existing knowledge in a way that resonates with their beliefs about the environment and relates to their daily experiences. For this, it is essential to present global issues at a *human scale,* which may be achieved by focusing on local issues and concerns or by using characters to illustrate the impacts they might be facing (Kearney, 1994). By associating climate change to the mental "here", within everyday life, rather than something that is happening "out there", it is situated within the realm of social and personal actionability (Yusoff and Gabrys, 2011). Moving from an issue-based focus towards *action-based conceptualisation* of climate change strengthens people's sense of agency for climate action, where stories about others taking action potentially foster social learning and enhance empowerment (Meyer et al., 2020). By making a story concrete and actionable, tailoring the message to the values, interests and worldviews of different audiences, it is possible to present the science in a way that is more approachable, meaningful and personally important (Nisbet, 2009; O'Neill and Nicholson-Cole, 2009; Moezzi et al., 2017).

Further, the tone of the stories and the feelings they evoke is important. While dramatic and shocking representations of climate change impacts may successfully capture people's attention, the feeling of helplessness such messaging often generates can be counterproductive. Instead, non-threatening and *positive messaging*, focusing on agency and opportunity, strengthens people's belief that they can improve their situation, and tends to promote proactive action, a defining feature also of the normative future visioning processes introduced earlier (O'Neill and Nicholson-Cole, 2009; Meyer et al., 2020; Pelling et al., 2023). To avoid future discounting, where future rewards are perceived as less valuable than immediate ones, it is commonly recommended to use language in the *present tense* even when referring to the future (Hill et al., 2008). References to scientific uncertainty are also not encouraged because it is often seen as an obstacle to assimilating climate information. Rather, the use of *certainty language* that removes doubt from the stories, helps to promote confidence in their messages (Budescu et al., 2014; Jack et al., 2020).

Finally, it is important to differentiate between *truth* and fact, as that may allow scientists to become better storytellers by finding ways in which truths about the changing climate and its impacts can be communicated in ways that do not depend solely on exchanging pure facts (Harris, 2020). It has been argued that there are parallels to be drawn between stories and climate models, that while they should be taken seriously they should not always be taken literally (Dillon and Craig, 2021). By taking a critical stance towards truth and emphasising communication, stories draw on discourse analysis, which focuses on how language conveys meaning. "It is not an environmental phenomenom in itself that is important, but the way in which society makes sense of this phenomenon" (Hajer and Versteeg, 2005, p. 176). However, when referring to truth and facts, adaptation-stories need to be clearly distinguished from the rhetoric used in so-called post-truth politics, fake news and disinformation that has become increasingly prevalent today. Such concerns demand a rigorous framework for developing stories that, in contrast to post-truth, highlights the importance of scientific evidence while recognising that other forms of evidence are also needed in public reasoning (Dillon and Craig, 2021; Groves, 2019; Jones and Anderson Crow, 2017).

3. An approach for the co-creation of adaptation-stories

3.1. Elements of a climate change adaptation-story

Several concepts associated with climate change impacts and adaptation are central to this paper, but these have varied, context-specific interpretations in the literature. For this reason, at the end of the paper we provide a glossary of definitions for some key

elements contributing to the concept of climate change adaptation-stories. We argue that adaptation policy is designed to address the impacts of climate *change* (emphasis intended), where climate varies beyond the coping range for impacts expected from natural climate variability alone. Thus, our focus is on impacts of changes that can be attributed, at least in part, to human activity.

Though adaptation policy is primarily directed towards those impacts of climate change that are judged to be adverse and pose risks, we recognise that some changes may offer opportunities, while many will be neutral. Failure to adapt may not only lead to costly damage from adverse impacts but can also imply costs through missed opportunities to take advantage of the benefits. Correspondingly, climate change adaptation-stories can be cast in the context of *notable climate change impacts* that may be detrimental, beneficial, neutral or a mixture of these but, above all, they are meaningful and described based on assumptions about future climatic and non-climatic impact-drivers and adaptation. Their main function is to illustrate, through the lenses of different stakeholders, how climatic and non-climatic conditions (either observed or based on scenarios) can affect natural systems, assets and livelihoods, and how these effects can be addressed (or not) through adaptation. Note, importantly, that to allow a more balanced appreciation of different kinds of climate change impacts, definitions are used that depart from those of the IPCC risk framework commonly employed in adaptation analysis (which emphasises adverse impacts). Vulnerability is replaced with sensitivity and a neutral definition of exposure is adopted (see Table A1 in the Appendix for terms used in this paper).

3.2. Framework for analysis

We now conceptualise, in generalised terms, an analytical method suggested for co-creating climate change adaptation-stories with local stakeholders and experts. We have identified five main steps that are indicated in Fig. 1. These are detailed in sequence below, and are then illustrated in Section 4, which presents an example of an adaptation-story relating to a real-world situation in Finland.

3.2.1. Step 1: Co-defining a notable climate change impact

This step identifies climate-related impacts that are "notable" for stakeholders in a region, which may require adaptive behaviour to be explored in the stories. They may relate to already occurring, unusual or unprecedented, weather events (flooding, heat, drought or storms), or impacts of slow trends, such as in growing seasons or snow cover duration. Alternatively, impacts may be those anticipated in the future, based on future climate projections combined with socioeconomic changes that may alter exposure and sensitivity. For example, an ageing population that is more susceptible to heat-related mortality and morbidity may further exacerbate the future burden on health and welfare services as summer heatwaves increase in frequency and severity. Identifying such notable impacts requires stakeholder dialogue and expert consultation, as different stakeholders will have different experiences of the same climate change impacts, which offer valuable insights for adaptation.

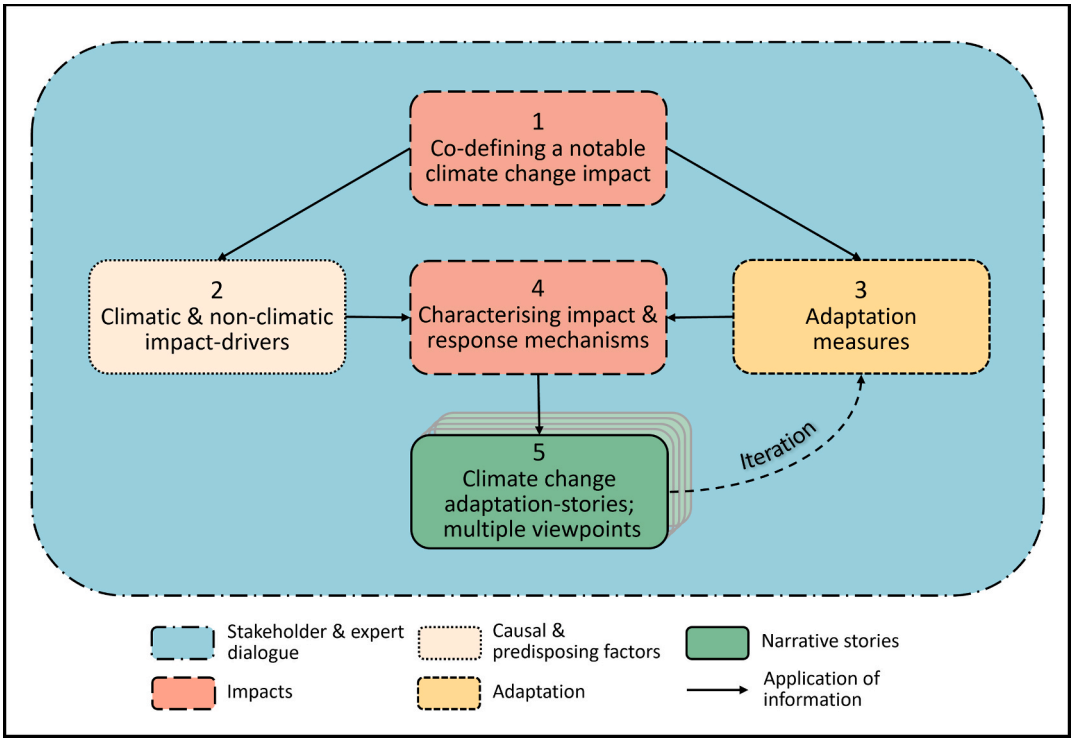

Fig. 1. Five-step generalised analytical method for co-creating climate change adaptation-stories with stakeholder iteration indicated as a curved, dashed arrow.

While the types of climate change impacts of importance to stakeholders may be fairly straightforward to identify in broad terms (e.g. flood risk to infrastructure or health effects of heat), what makes them "notable" is more subjective and requires closer examination. Real world outcomes derive from specific circumstances, exposures, tolerances and predisposing factors. In quantitative terms, a notable impact may be defined as a climate change impact that exceeds a critical threshold level deemed worthy of note by relevant stakeholders and experts (see Glossary).

3.2.2. Step 2: Co-identifying the major climatic and non-climatic impact-drivers

This step is concerned with identifying the specific types of climatic and non-climatic factors responsible for a given notable climate change impact. The types of metric employed by meteorologists to identify climatic impact-drivers (CIDs – defined by weather variables, Ranasinghe et al., 2021), such as thresholds of magnitude, frequency or rate of onset, are necessary but not sufficient for describing thresholds of impact. Other non-climatic impact-drivers (NCIDs –European Environment Agency, 2024) also come into play.

For instance, a heatwave event is an example of a temperature-related CID which, over a given duration, may have adverse effects on elderly people. However, these effects vary across the population, depending on predisposing NCIDs affecting *exposure* to the heatwave event (such as housing type or environmental quality) as well as factors affecting *sensitivity* to the event (like health status or access to services). An additional predisposing factor for a notable impact is the level of adaptation response that may already be in place to address such adverse heat events (e.g. early warning systems of weather forecasting or improved healthcare preparedness). This is indicated as a yellow box in Fig. 1, and see section 3.2.3, below). In contrast to its health effects on the elderly, the same heatwave event may be regarded as a boon to tourism at seaside or lakeside resorts or by opening a suitable window for harvesting cereal crops in agriculture. Here the inherent sensitivity to a heatwave event (e.g. through economic or operational benefits of hot days) can be regarded as a positive rather than adverse feature.

The focus of this study is on adapting to future climate changes that exceed natural climate variability, so a notable impact should be consistent with impacts estimated under projected anthropogenic climate change (see Glossary). This way, any adaptation options that are included in the adaptation-stories can be linked directly to local conditions anticipated under a changing climate.

3.2.3. Step 3: Co-evaluating adaptation measures for ameliorating or exploiting impacts

This step is crucial for analysing the types of adaptation measures that might be appropriate to responding to a given notable impact. Some adaptation may already be ongoing which, if known, can be expected to be part of an adaptation-story. However, there are many systems, assets and communities for which adaptation planning is at an early stage. Even where adaptation has begun, the accelerating pace of climate change suggests that continued and intensified adaptation efforts will be required in the future.

Step 3 draws on the experience and insights of the same experts and stakeholders responsible for identifying the notable impacts in Step 1, but it can also involve a wider group of actors with skills and resources for strengthening the adaptation narrative. The step requires identification of these additional experts along with processes of engagement to discuss adaptation options for addressing the impacts and viewpoints emerging from Steps 1–2. Considerations of how such interventions might affect the identified impacts would then be addressed in Step 4, in some cases based on adaptation modelling and always requiring expert and stakeholder input. This step may introduce additional perspectives from actors responsible for implementing adaptation, often benefiting from innovative engagement methods for imagining future adaptation. For example, one possible source of insights into adaptation to a changed climate is through the use of spatial analogues, regions in which the climate today resembles projections of future climate in a region of interest. The potential utility of analogues is reviewed in more depth by Ford et al. (2010).

3.2.4. Step 4: Characterising impact and response mechanisms

A recent review of future visioning exercises for adaptation concluded that they rarely made use of potentially valuable information generated by otherwise high-profile vulnerability and risk assessments (Nalau and Cobb, 2022). Here, on the contrary, this step aims to assemble the best available knowledge concerning the causal mechanisms and circumstances describing outcomes and responses of relevance for a notable impact. It establishes the quantitative association between the impacts and their driving variables identified in Steps 1 and 2, clarifying the levels of impact outcomes or thresholds that stakeholders regard as notable. It also accounts for possible adaptation interventions identified in Step 3. Two main approaches can be used, including combinations of these.

First, examining notable past impacts, while providing useful information in their own right, may offer insights into potential future impacts of the changing climate. Such an empirical approach benefits from drawing on impacts that have already occurred, enabling descriptions of contemporary experiences and facilitate discussions on adaptation options for the future. However, past impacts can only offer a partial guide for future adaptation since future climatic conditions are projected to shift progressively beyond the range of historical precedents.

An alternative approach is numerical simulation using impact models that represent the causal processes based on quantitative data and a given set of assumptions about the impact-drivers. Some impact models can also be used to simulate the effectiveness of adaptation options (Holman et al., 2019; Kondrup et al., 2022). However, the application of impact models requires expert knowledge, and the outcomes of more complex models can be challenging to interpret, especially in a manner familiar to stakeholders.

Adaptation-stories can make use of both or either of empirical and model-based sources analysed in Step 4, depending on the target audience and climate-sensitive systems in question. Nonetheless, a crucial ingredient for an effective story is that it captures the shared interpretations of the experts and stakeholders involved in their co-design.

3.2.5. Step 5: Co-developing climate change adaptation-stories

In this step researchers and stakeholders co-develop the adaptation-stories. While the scenes for a climate change adaptation-story are grounded on scientific evidence, their expression relies entirely on co-development. Techniques such as "positive deviance" or "appreciative inquiry" may assist in finding solutions in an empowering way. Positive deviance focuses on individuals or groups who find better solutions to problems via uncommon and novel behaviour, even when everyone else has access to the same resources and challenges (Singhal and Dura, 2017). Appreciative inquiry highlights strengths and successes to help people recognise the potential within any given situation (Armstrong et al., 2020). Stakeholder engagement can be conducted through workshops or interviews, but questionnaires do not facilitate the crucial co-creation process.

Specific emphasis is to be placed on stakeholder selection and in striving towards equity, to ensure that all relevant actors get the chance to be heard. Examples of alternative viewpoints could be offered by people working on the service provider side and by the users of the service, or by producers and buyers of goods. The target audience is also specific to each case. For example, it may comprise: different actors associated with a particular activity, where stories facilitate focused discussion; members of the general public, for raising awareness; or decision-makers, for whom concrete and relatable examples may be most useful.

The stories themselves may be drafted by researchers or in collaboration with stakeholders, depending on what is mutually agreed. The narrative style needs to be accessible to the target audience, with a consistent structure and format. Tailoring the story for specific audiences improves its effectiveness, even when addressing the very same climate change impact. Adaptation-stories may feature characters, a familiar setting, and a plot that navigates the characters from impacts to solutions, emphasising any gains achieved. While positive messaging has its benefits (see section 2.3), negative messaging can also be useful. It can highlight the potential implications of inaction (Rodríguez-Labajos, 2013) or possible effects of maladaptation, such as adaptive responses providing short-term benefits at the expense of longer-term losses, or responses that benefit adaptation at the expense of mitigation or other sustainability goals such as biodiversity (Juhola et al., 2016). Regardless of the chosen approach, it can be beneficial to balance clarity and conciseness with informative and usable content. Presenting several perspectives, as different versions of the same story, allows deeper exploration of different adaptive responses to the same climate change impact. The perspectives may also be aligned with scenarios, such as SSP narratives, to represent how impacts and adaptation may differ depending on the context.

There are useful protocols or checklists available for the drafting of stories (e.g., Jones and Anderson Crow, 2017; Hutchins, 2020). For the adaptation-stories outlined here this could typically involve first agreeing with stakeholders on the key messages to be conveyed in each story, which depends on the target audience and purpose of communication. Then relevant supporting information is distilled in summary form from various sources (e.g., literature, model-based analysis, stakeholder discussions), whether quantitative or qualitative and addressing uncertainty as needed. This material is usually organised according to the narrative structure to be adopted (e.g. in a tabular form), drawing on each of the four steps of analysis shown in Fig. 1. We illustrate this in the next section, where we have deconstructed a story into its component parts. The co-creation process should also allow stakeholders to review and give feedback on the drafted stories, to ensure their views and voices are appropriately presented. This is indicated by a dashed return arrow in Fig. 1, which may require several iterations before achieving an acceptable outcome.

Aside from the narrative form itself, there are other devices that might prove to be useful in communicating the stories. Images that characterise the key features of the story may offer helpful support to the text, and in some cases technical diagrams, designed for a specific target audience, can further enhance the message.

Finally, it is important to communicate clearly the purpose and limitations of the stories, as well as the steps taken to construct them. This includes referring to the scientific evidence supporting them along with associated uncertainties and assumptions and emphasising that their role is to initiate conversation and integrate knowledge rather than to provide predictions of the future (Jack et al., 2020).

3.3. Trustworthiness, replicability and durability of stories

While the foregoing analytical steps focus on constituent elements of the adaptation-stories themselves, their validity and applicability also rely on details of the co-creation process. In studies such as this that employ qualitative messaging, the concept of validity can be challenging, and we concur with those analysts who favour an alternative descriptor, trustworthiness. This is characterised by a clear decision trail that is transparent enough for reproducibility, using strategies where applicable that account for such issues as bias, stakeholder validation and triangulation of data sources (Noble and Smith, 2025).

Stories represent subjective interpretations of the co-creation teams involved and the specific aspects being highlighted. Though this introduces diversity, it can also offer richness that may resonate in a local context (Riedlinger et al., 2019). Moreover, stories are built on a scientific understanding of how future changes in climate and socioeconomic context can influence the notable impacts of relevance, additionally drawing on material gathered from interviews of key stakeholders. Hence, it may be supposed that stories prepared by different co-creation teams on the same theme and according to similar protocols are likely to share many of their most important features in common. However, if doubts remain concerning representativeness or replicability, it would be necessary to expand the analysis, for example, by co-creating stories with alternative author teams using the same and/or split samples of the interview material. The wider applicability of stories could also be explored, for instance by undertaking parallel co-creation exercises for similar cases in different locations.

The lasting relevance and durability of stories may also be questioned, as background conditions evolve, scientific and technological knowledge advance and adaptation priorities shift. An obvious approach here could be to revisit the storytelling exercise periodically, and then either update previous stories or embark on fresh analyses for newly defined notable impacts. Through the integration of different types of knowledge and consideration of alternative futures it may also be possible to evaluate and possibly

contest heuristics or rules of thumb assumed through past successes, or trends that may not hold true under future changes (Nalau et al., 2021).

Adaptation-stories are designed to raise awareness and encourage engagement, so it would also be important to evaluate how they are received by their target audience. Though evaluation of the legitimacy and effectiveness of stories is not part of the analytical process addressed in this paper, some considerations are offered in the discussion.

4. Illustrating the approach: adaptation to heat-related climate change impacts at Seinäjoki Central Hospital, Finland

In this section we illustrate how the foregoing analytical procedures have been applied in the case of climate change adaptation-stories for the healthcare sector in Finland. These relate to the renewal of Seinäjoki Central Hospital (SCH), located in South Ostrobothnia in western Finland. The hospital was built in the 1970s and serves a population of ~192 000 people (in 2022). A project entitled Hospital 2040 envisions the need for a profound transformation of the hospital complex into a customer-oriented, renewed and resource efficient institution by 2040. During its future lifespan, the renewed hospital should also be climate-resilient (Saarremaa, 2021). In this context, adaptation-stories were used to illustrate and to inspire thinking about the options for adapting the hospital complex to the likely impacts of projected future climate in the region.

The needs of the Hospital 2040 project dictated choices of length, style and plot, notable impacts and related applicable adaptation measures, whose perspectives were portrayed, and the future time period in which stories were set. A decision was made to embed three stories in the project's internal report, each approximately 0.5 pages long (Jouppila et al., 2022). It was considered important to write the stories from the perspective of a "future we want" rather than a "future we fear", so the focus was on describing successful hospital design with improved climate resilience. Two perspectives prioritised were of a hospital engineer responsible for managing the functioning of the hospital buildings and of a nurse responsible for patients during a future heatwave in the 2040s. A third story was written from the perspective of a patient, focusing on a slip and fall injury due to slippery winter conditions (see also Ruuhela et al., 2025 for a comparable story of an actual incident). Stories were written in the first person and designed to integrate a description of the future climate and socio-economic context, aspects of exposure and sensitivity relevant for each story and the impacts of the relevant climate hazard under given circumstances, highlighting various adaptation and mitigation measures that would have been implemented by 2040 to increase preparedness to future changes. Key information on adaptation measures used as a basis for drafting the adaptation-stories was obtained from surveys conducted by Saarremaa (2021) and among hospital staff as part of the Hospital 2040 planning process in spring 2022. Survey results were complemented by insights from 20 in-depth interviews of the hospital staff working in different roles. The nurse's account is reproduced in Box 1, with a comparable account from the hospital engineer's perspective included in Supplementary Material (the full set is planned to be published elsewhere in Finnish using local dialect). Numbers inside square brackets [] refer to Table 2 that lists information supporting the statements made in the story and linking them to the analytical steps (1–4).

5. Discussion

In this paper we have proposed a five-step analytical method for co-creating climate change adaptation-stories with local stakeholders and experts. We have illustrated its application in facilitating discussions between different actors about climate change adaptation needs in the context of a hospital renewal project in Finland. The motivation to use stories as a means of science communication stemmed from their potential to reach a wide range of audiences extending beyond the research community. Our hypothesis is that by translating complex information into an accessible format that ideally speaks to the audience, this may then spark their imagination (e.g., Mackenthun, 2021). The role of imagination is nicely encapsulated by Jiménez-Beltrán in the foreword of Alcamo et al. (2001): "In our path to sustainability we need to look beyond tomorrow because to create a better future we must be able to imagine it". An ability to imagine is seen by some almost as a prerequisite for planning and action (Van Leeuwen, 2016).

The use of narrative approaches is well known as a scenario communication tool. While there are similarities and overlaps between scenarios and adaptation-stories, there are also clear distinctions between them. Scenario development increasingly involves participatory narrative processes for collating opinions about alternative futures to inform planning (Nalau and Cobb, 2022), whether these are exclusively normative (e.g., many NFV applications – Pelling et al., 2023), exploratory (e.g. see review by Pedde et al., 2025), predictive (e.g., Shepherd, 2019) or hybrids of these (e.g., Frantzeskaki et al., 2019 for Europe). In contrast, adaptation-stories do not aim to guide planning directly, but rather strive to function as conversation starters between actors that pave the way for refinement of knowledge and understanding in the decision-making process The decision to place local actors and solutions for adapting to a changing world at the centre of the stories was motivated by the need to strengthen the inclusion of adaptation considerations in discussions around practical planning (and see, for example, Harcourt et al., 2021). Moreover, the construction of stories is not governed by any particular paradigm other than effective communication. While usually set in the future they need not necessarily be so, and they may characterise positive adaptation outcomes or alternatively effects of inaction or of limitations or barriers to adaptation.

5.1. Utility of the approach – how readily can the approach be applied to real world situations?

This framework for constructing adaptation-stories can be readily applied in different settings where stakeholder engagement can be arranged. The step of characterising impact and response mechanisms (Step 4) can often present challenges of data and model availability, but even with limited resources it may be possible to rely on published analyses of such impacts and whatever pertinent

Table 2
Information supporting the statements made in the nurse's story (Box 1). Numbers relate to those indicated in the story in square brackets [] linking the statements to the analytical steps of the framework (1–4).

1 Co-defining a notable climate change impact	Effects of heatwaves on the hospital functionality as well as on the wellbeing of staff and patients was co-selected as the notable climate change impact based on engagement with a range of actors having direct involvement with the hospital in various capacities, the findings of an academic thesis on heat impacts in Seinäjoki Central Hospital (SCH)[a] as well as results from national-scale studies of heat impacts on the healthcare sector[b,c].
2 Climatic (a) and non-climatic (b & c) impact-drivers	
2a Climatic impact-drivers	
2a.1	Past and future heatwaves in Seinäjoki were analysed using the heatwave extremity index[d,e]. Five of the six most intense heatwaves exceeding 20 °Cd over the past 65 years (1960–2024) occurred after 2000, with the strongest in 2018 (59.5 °Cd over an event that lasted 20 days), indicating a rise in extreme heat events. This trend is projected to continue in the future, with the mean annual number of heatwave days exceeding 20 °C projected to increase by 10 to 15 days in South Ostrobothnia by the 2040s[e].
2a.2	Heavy rainfall has been observed to increase across regions in Finland, including at a station located in Seinäjoki, with an increase of 0.3 heavy rainfall days per decade. Projections indicate that both intensity and frequency of heavy rainfall will continue to increase in South Ostrobothnia by 2050s and throughout the century[f].
2b Exposure (non-climatic impact-drivers)	The hospital is an integrator of the heat burden on the entire catchment area serviced by and including the hospital staff and premises. The number of elderly people (over 65 years) in the South Ostrobothnia region has grown steadily over the years (from 20,867 in 1972 to 51,165 in 2022) and is projected to continue to do so before stabilising in the future. By 2040, every third person living in South Ostrobothnia is projected to be older than 65. The age dependency ratio is projected to increase from the 2022 value of 74.4[g] to 81.9[h], suggesting that in the future more elderly will be needing to rely on public services such as home care for help instead of on family members.
2c Sensitivity/vulnerability (non-climatic impact-drivers)	Heat mortality is highest among the elderly—particularly those over 75—as well as long-term hospital patients and institutional residents. Chronic illnesses increase vulnerability, and women are more susceptible than men[i,j]. Between 2019 and 2021, morbidity in the region, particularly for diabetes, was higher than the national average. Primary healthcare use and overweight rates in those over 20 were also the highest across Finnish regions in 2020[k]. Co-produced narrative extensions of the global shared socioeconomic pathways (SSPs) for the 2050s in Finland suggest that the health care burden will rise in three out of four alternative future pathways investigated, due to unhealthy diets and an associated increase in morbidity[l].
3 Adaptation measures	
3.1	Criteria for hot weather warnings issued for Finland[m] are based on health impacts of heat stress, particularly on mortality, defined with respect to daily mean temperature. The lowest national warning level is triggered on "hot days" when the daily mean temperature exceeds a threshold of 20 °C. Currently, the hospital lacks specific procedures for preparing for heat events. In the co-evaluation process the preparation of preparedness plans for long heatwaves, making use of heat warnings and associated impact estimates tailored to hospitals and rescue services, emerged as potential options to adapt to heatwaves.
3.2	Characteristics of a hospital building can considerably influence its exposure to heat inside the building and thus play an important role in patient-level heat-related mortality and morbidity during heat events[n]. In studies on residential buildings in Finland apartments have been found to warm up even during average summers, with the maximum hourly indoor temperatures in many cases exceeding 27°C[o,p]. At SCH, the dense built-up area of the hospital, extending widely across surfaces covered largely with asphalt, and the limited presence of trees and green area, increase the exposure of the buildings to heatwaves. In the oldest buildings, which will be 63 years old in 2040, the low floor height prevents installation of modern air conditioning. While some sections are equipped with shutters or blinds that shield the windows from the sun, others lack these. Adaptation options identified in the co-evolution process related to employing technical solutions to reduce heat impacts via improved shading and air conditioning, which are in line with findings from the literature on improving preparedness in the health care sector[b].
3.3	In the surgical units at SCH, heat-related problems were seen to be associated mostly with equipment management. In addition to heat, excess moisture in the operating theatres was seen to increase risks to patient safety due to condensing moisture on surfaces and instrument packages[a] issues identified also in a nationwide survey on heat impacts at Finnish hospitals. Co-identified adaptation options for managing humidity were again seen to relate to the employment of tailored technical solutions.
4 Characterising impact and response mechanisms	Extreme heat can trigger a series of harmful effects on the body. Prolonged exposure weakens the immune system, increasing susceptibility to infections and slowing recovery. Additionally, heat exacerbates existing health conditions like respiratory and heart diseases. This combination of factors can lead to serious complications, across age groups but especially in vulnerable individuals[q].

[a] Saarremaa (2021); [b]Kollanus et al. (2022); [c]Rapeli and Mussalo-Rauhamaa (2024); [d]Ruosteenoja and Jylhä (2023a); [e]Ruosteenoja and Jylhä (2023b); [f]Luomaranta et al. (2025); [g]Statistics Finland (2023); [h]Statistics Finland (2021); [i]Kovats and Hajat (2008); [j]Kollanus et al. (2021); [k] Etelä-Pohjanmaan hyvinvointialue (2021),[l]Lipsanen et al. (2025); [m]https://en.ilmatieteenlaitos.fi/warnings-on-hot-and-cold-weather; [n]Samuelson et al. (2020); [o]Farahani et al. (2024a); [p]Farahani et al. (2024b); [q]Kollanus and Lanki (2021).

local information is available. However, it is the local treatment of cases that allows each story to concentrate on those unique circumstances and solutions that are directly relevant for local adaptation.

Adaptation-stories can also be helpful communication tools for offering specific examples of outcomes that describe integrated climatic and non-climatic futures used as alternative scenarios. An example of this is under preparation for another region of Finland, where climate change adaptation-stories have been co-developed from the perspective of local dairy farmers attempting to maintain livestock health and milk production. There, the stories assume two contrasting global socioeconomic backdrops: one encouraging sustainability (SSP1), the other characterised by rising inequality (SSP4).[6]

[6] https://www.syke.fi/en/projects/finnish-scenarios-climate-change-research-addressing-policies-regions-and-integrated-systems#ssp1-sustainable-world-the-farm-is-adapting-to-climate-change-by-combining-tradi-tional-expertise-with-technological-innovations).

Box 1
Nurse Saarni in 2040.

"What a relief to be heading to work during this heatwave! Apparently, this year's is likely to be another record-breaker [2a.1]. The dry and hot weather has occasionally been interrupted by intense thunderstorms and heavy rains [2a.2], leaving the air warm and humid, like a cow's breath. In other words, it's been extremely uncomfortable – at least outside of work. Inside the hospital, however, the conditions are quite comfortable; so comfortable, in fact, that some of us actually prefer to work in July rather than take a vacation. I'm one of them. Even though the workload and number of patients increase during these heatwaves [1], it's still manageable to work here.

We always get a surge of patients during heatwaves [2b], particularly older adults with chronic illnesses. Most of them are women suffering from cardiovascular and respiratory symptoms [2c]. Many people also experience disruptions in their fluid and electrolyte balance during extreme heat, which can then affect their kidneys. Various infections tend to heal more slowly and may even require extended care. That said, the heat takes a toll on working-age people as well—we see them as patients, too [4]. Thankfully, we have contingency plans in place for different weather conditions, each with clear, concrete instructions that everyone knows how to follow. Heat warnings and impact forecasts are monitored closely [3.1].

In addition to the care itself, the hospital's comfortable conditions also help patients recover. The blazing sun doesn't overheat the building because the windows have automatic adjustable sunshades. We also have truly wonderful air conditioning: the temperature is just right, but even the most sensitive patients don't suffer from drafts. Moreover, modern building technology allows us to regulate humidity levels effectively [3.2].

Thanks to these systems, we can perform surgeries here even in the middle of summer that require relatively low temperatures. The stable conditions also ensure that our tools remain sterile and equipment functions as it should [3.3]. This way, we can provide the best possible care even during heatwaves.

Well, time to go—duty calls!

5.2. Messaging and the role of dialogue – evolution of stories according to stakeholder needs

In the Seinäjoki hospital case, co-creation with local actors was seen as instrumental in focusing the work on topics directly relevant to the case at hand. Stakeholder engagement has also been suggested for increasing uptake, acceptability, legitimacy and effectiveness of research results (Sherman and Ford, 2014). In the analytical framework for constructing adaptation-stories, interviews of stakeholders provide first-hand information about the varied dimensions of how a notable impact is experienced and how this may differ depending on who is experiencing it (in this case standpoints from representatives of the medical and maintenance staff). Moreover, the inclusion of local actors offers them an outlet for their voices, ideas and concerns to be heard, and expanding or adopting alternative adaptation imaginaries can help localise adaptation practice (Olazabal et al., 2024a).

It was felt that effective treatment of adaptation in discussions on hospital planning would benefit more from inspiring tales of finding solutions than from stressing the severity of the situation, which tends to be the message that is usually communicated (Harcourt et al., 2021). While there is evidence that in certain cases negative messaging can be more effective in triggering action-taking (Morris et al., 2019; Witte and Allen, 2000), repeated fear-based messaging over time may lead to "apocalypse fatigue" (Nordhaus and Shellenberger, 2009). Alarmist messaging also may resonate less with those who have limited personal experiences of serious climate change impacts (Martel-Morin and Lachapelle, 2022), which indeed has largely been the case in Finland compared to the level of impacts experienced in many other regions of the world.

The effectiveness of stories depends to a large degree on the ability to write compelling and engaging accounts that at the same time communicate the important scientific messages. This process can benefit from the use of professional storytellers and language editing services. Additionally, the use of artists for creating illustrations for the stories, especially if these introduce a familiar local context, can add to the ability of the stories to engage the audience (and see examples for the Finnish dairy case described above). A visual representation of the stories, capturing their essence, can also help some to assimilate the information better (Cluley et al., 2021; Olazabal et al., 2024b; Loroño-Leturiondo and Olazabal, 2025). However, others may find an illustration distracting (away from the story) or contradictory (e.g., if it differs from one's own mental image of the story), so their use is a matter of judgement.

5.3. Legitimacy – how to judge the relevance and effectiveness of the stories

Of course, the proof of the pudding comes in the eating, and the ultimate judgement of an adaptation-story can be found in its uptake and effectiveness. Arguably, an evaluation of a story's legitimacy could qualify as an additional step of the analytical method shown in Fig. 1, though we prefer to keep it separate. It is distinct from the iterative stakeholder feedback employed in co-creating stories, as it should involve independent actors who have been exposed to the stories. Certainly, *ex post* analyses of whether and how adaptation-stories have been adopted and applied, involving a range of survey, interview and discursive methods, could yield valuable insights into the efficacy of the approach. There are also formal methods for evaluating the impact of narratives on beliefs, attitudes, intentions and behaviours (e.g. Braddock and Dillard, 2016; Rahmani et al., 2025). Such follow-up analysis could aid the

refinement of stories, offering experiences and lessons to inform future exercises (see, for example, Jack et al., 2020).

6. Conclusions

In this study we have proposed a formal, bottom-up, science-based approach for portraying past or imagining future adaptation that we have labelled adaptation-stories. The co-development of adaptation-stories is conceptualised as a participatory process comprising five steps. We argue that carefully constructed adaptation-stories may empower local actors by addressing climate change adaptation from the perspectives of specific lives and livelihoods. We have illustrated this for a case involving the renewal of an hospital, reflecting future standpoints of different actors adapting to heat-related challenges. Finally, we have described some alternative methods of presenting adaptation-stories as well as evaluating their legitimacy.

This is just a first attempt to formalise a method that we suggest could be of value in offering support for adaptation planning under unavoidable climate change. Of course, there are many subjective elements in such approaches that may undermine their credibility and legitimacy. Possible extensions of the approach could address these, for example by:

- Conducting a new exercise for the same issue but with an alternative set of stakeholders and a different research team, to see how the resulting stories compare to parallel versions (i.e., to test replicability).
- Undertaking the same exercise several years later, ideally with the same stakeholders, to see if attitudes have changed (i.e., to appraise durability).
- Formalising evaluation processes for judging the effectiveness of adaptation-stories in meeting their communication objectives (i.e., to assess legitimacy).

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CRediT authorship contribution statement

Nina Pirttioja: Writing – review & editing, Writing – original draft, Visualization, Methodology, Conceptualization. **Päivi Abernethy:** Writing – review & editing, Investigation. **Sami Ahonen:** Writing – review & editing, Investigation, Formal analysis. **Stefan Fronzek:** Writing – review & editing, Methodology. **Tiina Jouppila:** Writing – review & editing, Investigation. **Kirsti Jylhä:** Writing – review & editing, Project administration, Investigation, Funding acquisition, Conceptualization. **Niina Kautto:** Writing – review & editing, Methodology. **Sanna Luhtala:** Writing – review & editing, Writing – original draft, Investigation, Formal analysis. **Taru Palosuo:** Writing – review & editing, Project administration, Methodology, Funding acquisition, Conceptualization. **Karoliina Rimhanen:** Writing – review & editing, Methodology. **Reija Ruuhela:** Writing – review & editing, Writing – original draft, Supervision, Investigation, Formal analysis. **Kirsti Saarremaa:** Writing – review & editing, Investigation. **Timothy R. Carter:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Project administration, Methodology, Funding acquisition, Conceptualization.

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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Appendix 1

Table A1
Glossary of definitions used in this paper.

Element	Definition
Adaptation options[a]	The array of strategies and measures that are available and appropriate for addressing *climate change adaptation.*
Climate change adaptation[b]	The process of adjustment to actual or expected climate change and its effects, in order to moderate harm or exploit beneficial opportunities.
Climate change adaptation-story[c]	An account of a real or imagined experience of adjusting to a changing climate. Set in the present or future, stories describe livelihoods affected by climate change from the perspectives of different local stakeholders needing to adapt.
Climate change impact[c]	An effect of climate on an exposed system or asset that can be attributed, at least in part, to anthropogenic climate change.
Climatic impact-driver (CID)[a]	Physical climate system conditions (e.g., means, events, extremes) that affect an exposed system or asset. Depending on system tolerance, CIDs and their changes can be detrimental, beneficial, neutral or a mixture of these.
Exposure[a]	The presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be affected.
Non-climatic impact-driver (NCID)[c]	Socioeconomic or other environmental conditions that influence the susceptibility (*exposure* or predisposing *sensitivity*) of a system or asset to *climate change impacts*. NCIDs and their changes, like CIDs, can be detrimental, beneficial, neutral or a mixture of these.
Notable climate change impact[c]	A climate change impact that exceeds a critical threshold level deemed worthy of note by relevant *stakeholders & experts.*
Sensitivity[a]	The propensity of an exposed system or asset to be affected, either adversely or beneficially, by climate variability or change.
Stakeholders & experts[c]	Any person or entity with a stake in and/or expertise on a given exposed system or asset sensitive to *climate change impacts.*

[a]Largely based on the IPCC AR6 Glossary but modified for use in this paper (see section 3.1); [b]Taken verbatim from the online IPCC AR6 Glossary https://apps.ipcc.ch/glossary/; [c]Unique for this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.crm.2025.100785.

Data availability

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

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