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Aspirations versus adaptive achievements in the face of climate change in Sri Lanka

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This research explores the linkages between threat perception and adaptive behaviour in the face of climate change in Galle, Sri Lanka. We use an analytical framework to analyse the complexity of aspiration versus adaptive practices, centring around the synthesis of threat perception, vulnerability, adaptive capacity and livelihood resilience. Our findings reveal that individual threat perception incentivises climate adaptation strategies, bolstering livelihood resilience. However, unfavourable societal circumstances affecting the participants significantly impede the implementation of these resilience strategies. In addition to a knowledge gap and lack of climate change awareness in popular discourse, we observe a conspicuous discrepancy between individual aspirations and adaptive capacity with the ongoing economic crisis and the need for governmental climate legislation at the time of research. This research, therefore, emphasises a nuanced approach to researching climate change adaptation, considering the gravity of societal circumstances that delimit how individuals can engage in livelihood resilience strategies.

Climate change has been widely acknowledged as a significant threat to natural ecosystems as well as human civilisation in the twenty-first century and beyond. Its impact extends across all dimensions of the socio-ecological environment, encompassing biodiversity, agriculture, settlements, and health[1]. While the effects of climate change will continue to be experienced diversely across regions, its drivers and consequences are global. No country or region is immune[2]. However, evidence underscores that the most severe ramifications of climate change will be felt in developing nations, where the population is most vulnerable due to their high dependency on climate-sensitive livelihood options and their limited capacity to adapt to climate variability and extremes[3,4]. Due to rising temperatures, intensifying extreme weather events, and rising sea levels, densely populated, low-lying tropical coastal communities are especially vulnerable to climate threats[5,6]. The rapid urbanisation of these coastal areas further amplifies their exposure as growing populations coincide with global sea level rise, flood hazards, and escalating risks of infrastructure damage, displacement, and job loss[6,7]. Climate change thus seriously threatens communities that depend on oceanic resources like agriculture and fishing[5]. One such threatened tropical coastal city is Galle, located at the southwestern tip of Sri Lanka. Its low-lying geography, tropical wet climate, lack of coastal flood protection, and ongoing restorations from the 2004 Indian Ocean tsunami exacerbate its susceptibility to climate risks[8].

Enhancing adaptive capacity is crucial for individuals facing climate threats to increase long-term livelihood resilience[5,9]. In understanding individual risk response, it is crucial to assess how individuals perceive these risks. This research asserts that the degree to which climate risks are perceived as such is determined through a combination of subjective knowledge and experience, cognitive mechanisms, and climate vulnerability and exposure. When faced with risks, we assume that individuals attempt to attain livelihood resilience by engaging in adaptive behaviour. Therefore this research aims to link cognitive tools and behavioural tendencies in a climate risk context. Grounded in a livelihood resilience approach, we establish an analytical framework that emphasises the iterative process of threat perception and adaptation in increasing livelihood resilience in the face of climate change (see Fig. 1). Accordingly, we propose that the interaction of climate change knowledge, vulnerability and adaptive capacity determines how a person perceives a threat, which in turn determines how they engage in adaptation strategies in the face of both slow- (e.g., temperature and sea level rise) and rapid-onset (e.g., tsunamis and flash floods) environmental events. Despite ample research on threat perception, adaptive capacity, and livelihood resilience, a lack of exploration of the synthesis and co-dependency of these mechanisms persists. Therefore, we apply an analytical framework (see Fig. 1) drawing on the interaction of key mechanisms and theoretical approaches concerning livelihood resilience. The main research question is: *How do threat perceptions of climate change influence individual adaptive behaviour?* Three sub-questions were designed to support the main research question:

1. How do residents of Galle perceive climate risks?
2. To what extent do residents of Galle perceive their livelihoods to be at risk due to climate change?

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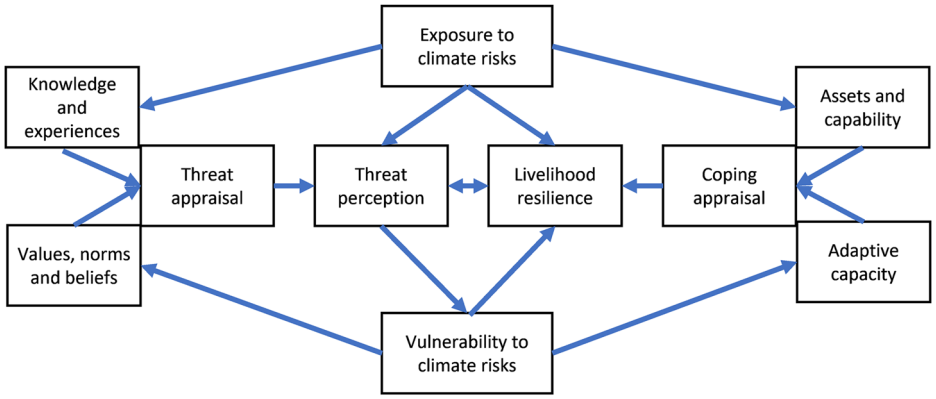

Fig. 1 | Individual perception and adaptation to climate change. The analytical model integrates, not in any particular order, (i) exposure to climate risks; (ii) knowledge and experiences; (iii) values, norms and beliefs; (iv) vulnerability to climate risks; (v) adaptive capacity; and (vi) assets and capability to determine climate change threat perception and livelihood resilience. It centres around the two primary cognitive PMT mechanisms of threat and coping appraisal to ultimately determine livelihood resilience. The figure is modified from Mallick et al.[33].

3. In what ways do residents of Galle engage in livelihood resilience adaptation strategies in the context of climate change?

Even with its profound implications for society, the environment, and the economy, most people need help to recognize climate change quickly and accurately due to its gradual development. Slow-onset changes like desertification, droughts, and salinity especially are complex to identify[10,11]. Perceptions of climate change, however, are not solely influenced by tangibility. Research on environmental values identifies that values significantly impact how people respond to climate risks and establish a natural connection between place and decision-making[12]. Stern et al.[13] claim that values, fundamental beliefs, attitudes, and norms significantly shape behavioural intentions and behaviours. They argue that values are crucial in shaping one's worldview, affecting active behavioural choices. Moreover, Ives and Kendal[12] consider values not merely as mental, static structures but acknowledge their profound embeddedness in ecology and culture. They assert that "people's underlying values influence general beliefs about the environment and specific beliefs about the consequences of environmental change on the things they value"[12]. Other external factors also affect an individual's ecologically impactful behaviour. Dietz et al.[14] reveal how the availability of public transportation influences commuter decisions regardless of an individual's values. Additionally meaningful are the social milieu in which an individual is situated and their interactions with others. Similarly, O'Brien and Wolf[15] argue for a value-based approach to climate change vulnerability and adaptation which emphasizes that there are qualitative, subjective facets to climate change that are significant to individuals and cultures besides the objective, scientific measurements of its effects. Thus, individual environmental decision-making does not take place in a vacuum.

Whereas norms and values guide behavioural intentions, a person's worldview is often shaped by religious beliefs since these permeate all aspects of life, including livelihood, behaviour, cuisine, and customs[16]. Sri Lanka's predominant religions—Buddhism, Hinduism, and Islam—emphasize human-nature interconnectedness and acceptance of change[16,17]. Research conducted by De Silva[18] among Sri Lankan Buddhists reveals that individual disaster perceptions and coping in the aftermath of the 2004 tsunami seem to have been influenced by Buddhist beliefs on impermanence (*anicca*; everything is perpetually changing) and karma (*kamma*; one receives the results of their choices). Consequently, one's threat perception and interpretation of climate risks are in part affected by values and (religious) beliefs[19], alongside the vulnerability and adaptability to changing climatic conditions.

Climate change vulnerability, resilience, and adaptation are intricately interconnected concepts, increasingly considered through subjective values in which human agency is pivotal. They vary contextually and temporally across social groups, individuals, and nations. The synthesis of individual threat perception and adaptive capacity is crucial in increasing livelihood resilience in a climate vulnerability context. Climate change vulnerability encompasses susceptibility to damage from an external ecological threat, affected by exposure, sensitivity to impacts, adaptability, and coping capacity[4]. Moreover, it encompasses resilience: the capacity to rebound after disruption[20]. This research adopts a livelihood resilience approach, distinctly recognizing and emphasizing the diversity in risk perceptions and responses[21]. In countering the dominant viewpoint of communities as homogeneous, it emphasizes the importance of human agency for building resilience, integrates disaster management, adaptation, and empowerment[22,23]. A resilient system, therefore, can adjust to change and withstand stress while retaining its core attributes of structure, function, and identity. Adaptive capacity is a key component of resilience in the context of climate change[24,25].

Adaptation can be defined as making systemic, often value-based, changes to reduce climate vulnerability[15,26,27]. Within these systems, the conditions that enable people to anticipate change, adjust to it, limit its impacts, recover from it, and seize new opportunities are defined by the notion of adaptive capacity[5]. Adaptations can be planned or ad-hoc, driven by policy or individual initiatives, and affected by technological resources, financial capital, kinship networks, and institutional environment[28,29]. In this context, an individual is a component of a broader system that they depend on for favourable conditions and circumstances to enable or assist adaptation. For instance, a strong kinship network may facilitate access to financial resources and supportive labour to undertake physical adaptation measures, thereby boosting adaptive capacity[29]. In essence, adaptive capacity explains why some individuals and groups can innovate and adapt more effectively and swiftly to minimize harm and seize opportunities than others[30]. Given its alignment with vulnerability and threat perception, the Protection Motivation Theory is employed to analyse adaptive behaviour.

Introduced by Rogers[31], the Protection Motivation Theory (hereafter 'PMT') analyses the effects of fear appeals, focusing on cognitive mechanisms driving behaviour change[32]. Its core tenet is that, when presented with dangers, people use the two primary cognitive processes of "threat appraisal" and "coping appraisal" in determining appropriate adaptive behaviour. Threat appraisal assesses perceived threat seriousness, susceptibility, and vulnerability while coping appraisal evaluates one's ability to respond and avoid risk[33,34]. High threat severity, susceptibility, self-efficacy, response efficacy, low response costs, and maladaptive rewards drive adaptive responses and self-protective behaviour[35]. Kothe et al.[35] illustrate these variables of self-protective behaviour through the example of a farmer experiencing drought. Suppose a farmer thinks the severity of the drought threat is high. In that case, they are highly susceptible to drought on their property (susceptibility), there are favourable incentives for drought to occur (maladaptive response rewards), they are confident they can put drought mitigation practices into practice (self-efficacy), they are confident their adaptive practices will be successful in reducing the negative effects of the drought (response efficacy), and they have sufficient financial resources to put drought adaptation strategies into practice (response costs). Therefore, the PMT's central tenet is that achieving self-protection necessitates a process that includes assessing the threat and one's ability to cope with it[33].

The PMT originated in social and health psychology, expanding to a broader spectrum of decision-making fields[31,32], though its methodology remains quantitative. However, this research argues that qualitative methods can also explore the PMT variables through inductive reasoning, accommodating individual experiences beyond numerical scales. Invoking the PMT variables in qualitative research methods, such as in-depth interviews, structures the exploration of ideas, aspirations, perceptions, and experiences, elucidating threat perception's influence on adaptive capacity within various contexts. We can adapt interview guides to include the PMT variables in a semi-structured line of questioning, in which the in-depth interview allows for more context and details than a survey might. Expanding to qualitative research can thus deepen the understanding of the threat and coping variations affecting adaptive capacity and livelihood resilience.

The analytical framework (Fig. 1) integrates threat appraisal, adaptive capacity, and livelihood resilience theories within climate risk and vulnerability contexts. The framework underscores how the risk posed by environmental threats can be limited by adaptation strategies grounded in adaptive capacity and influenced by threat perception. Exposure and vulnerability, according to the IPCC[36], shape the socio-ecological elements of environmental hazards. Exposure identifies how severely a person or landscape is exposed to environmental threats, whereas vulnerability considers the degree to which individuals are or could be harmed by climate risks—both impact threat perception and livelihood resilience, though not in isolation. The PMT forms the crux of the framework, focused on threat and coping appraisal. Threat appraisal assesses threat seriousness and vulnerability, influenced by climate risk knowledge, experience, values, and beliefs. Coping appraisal, shaped by assets, capability, and adaptive capacity, measures response-ability. Adaptive capacity encompasses commitment, capacity, and willingness to adjust. Assets and capability include individual socio-economic attributes. These interdependent factors determine threat perception and resilience. On the other hand, resilience through effective adaptations decreases threat perception, reducing vulnerability. This dynamic system is influenced by unpredictable external individual and social events, which also shape livelihood resilience. Livelihood resilience is thus not merely an end-state but rather a back-and-forth process.

This qualitative research uses primary data collected through in-depth interviewing, supported by participant observation and small talk. The first author conducted 30 in-depth interviews in English, supported by a collection of experiences and stories through interactions with residents of Galle. Most interviews were conducted only in the presence of the participant and the researcher, but when a language barrier arose, a translator, a native Galle resident, was present. The researcher is aware that her background and position could have affected the data collection and findings. The use of English rather than Sinhala in the interviews and conversations could have limited the conveyance of a deeper understanding of experiences, ideas, and emotions. Moreover, having Asian and Dutch roots, the researcher is aware that her presence and position could reify neo-colonial sentiments in Galle, where many physical remains of the Dutch colonial period in Sri Lanka are present. To uphold ethical standards, the research design ensures confidentiality and anonymity of participant information. Pseudonyms are carefully chosen, and information that could identify participants is withheld. A possible limitation of this study includes the limited number of in-depth interviews due to time and financial constraints. The structure of the paper is as follows: Section "Results" presents the empirical findings, followed by the discussion of the findings in the context of the analytical framework. The methodology section presents the study site details and the research design.

Results

How threat perception evolves through knowledge and values, norms and beliefs

Ample variations in participant reports on threat perceptions underscores its subjectivity. It is challenging to reflect upon a diverse palette of individual perceptions as the degree to which cognitive, non-person specific, demographic, and identity-related factors played a role in shaping threat appraisal—ultimately determining threat perception—varied. We found knowledge of climate change especially to be an important indicator. Knowledge and awareness of climate risks generally lead to a higher threat appraisal, supported by a high perceived vulnerability and threat severity. Participants who were informed through their (self-)education, network, and/or occupation on climate change and pollution expressed concern about the high rate of inland deforestation, the absence of (plastic) recycling options, the effect of pollution by motorized vehicles, and the dumping of garbage on streets. However, while most participants identified structural changes in weather patterns, many did not understand climate change as a global phenomenon or had never heard of the term. Education on climate change is relatively new in Sri Lankan school curricula, contributing to these gaps in understanding. Accordingly, knowledge of climate change often corresponds with age, generation, occupation, and education level. Participants who had received no education or were enroled when school curricula did not include climate change had less knowledge of climate change consequences than younger participants or participants with theoretical educational backgrounds. Nuwan, a 67-year-old (traditional) paddy farmer, depends on his harvest for food and income, which has steadily declined due to excessive rainfall and a national fertilizer shortage. However, he was not inclined to plan for the next season, tending rather to abide by day-to-day prospects. Thereby, he reported low levels of stress or perceived threat, while many (familial) first- or second-generation participants perceived long-term, structural climate risks as threatening their livelihood. Manil, a 49-year-old tour guide, describes how he regularly has to cancel his walking tours due to heavy rainfall or extreme temperatures:

> The weather pattern affects my business because if it is too hot, I can't take the Europeans out and walk in the daytime […] especially the Europeans with their white skin. They can't tolerate this weather […] So these things you can't predict now. Sometimes, all of a sudden, it might rain.

Participants working in natural-resource or weather-dependent sectors, like Manil, admitted a loss of income, thereby becoming increasingly more vulnerable to climate change effects.

For those unfamiliar with the possible hazardous consequences of climate change, the perception of livelihood vulnerability hinged on other contextual factors. The unprecedented economic crisis that erupted in 2022 aggravated climate change's effects on livelihood vulnerability. Power cuts, inflation, and goods shortages impact various sectors, with agriculture, tourism, and fishing being most affected as a result of reliance on both climate conditions and essentials such as fuel and power. Similarly, changing climate conditions such as unexpected rainfall and increasing temperatures interfere with traditional Sri Lankan farming methods based on historical intergenerational knowledge. Paddy farmers generally depend on manual labour, however, some farmers have collectively invested in a rice harvester. While visiting a paddy farmer who wanted to start harvesting with the rice harvester, it started pouring. Such heavy rainfall events make the machine obsolete as the paddy fields turn muddy, reinforcing the capacity of traditional knowledge-based labour. Some participants felt their vulnerability in Galle left migration to another region or country as their only viable option. However, their lack of financial resources, attachments to the city, and familial responsibilities withheld them from doing so. Perceived livelihood vulnerability thus often coincided with weather conditions, although 'climate change' was rarely mentioned as a contributing factor. Altogether, participants demonstrated threat appraisal, entrenched in socio-economic vulnerability, unconsciously or indirectly aggravated by climate change.

Findings also show that knowledge and experience do not necessarily correlate; many participants directly impacted by climate change were not necessarily more knowledgeable about the notion of climate change itself. Notably, the 2004 tsunami was a significant event that only sometimes translated to a sustained threat perception. Most participants reported that their trauma faded over time and wasn't a source of anxiety anymore: the narrative of 'forgetting' is characteristic. In line with other participants, Suvik, a crime scene investigator who had to recover the bodies of the deceased in the aftermath of the tsunami, said, "We don't think about it now;

we forget it". Exposure to climate change or extreme events alone is thus not ultimately sufficient as a threat perception indicator.

In making sense of their climate change perceptions as well as searching for acceptance of the loss of livelihood or income, some Sinhala participants reflect on their Buddhist beliefs, which shape core norms and values. Particularly, they often mention the concept of karma as positioning climatic changes and providing guidance through the aftermath of the 2004 tsunami. One participant, for instance, said: "[P]lease what you have […] the view that there is God, so it's like that for a reason. It's like karma". Similarly, although she lives on the coastline and her house was damaged by the tsunami, Chaturi, a family restaurant owner, explains that living in a climatically vulnerable area does not necessarily encourage her to move to a safer region. She perceives hardship not as sudden and unwarranted but more as a natural consequence of past individual and collective actions (*kamma*). Therefore, she emphasizes having no feelings of fear towards possible climate hazards. Another participant, Kasun, said, "I'm not afraid to die," as his fear of extreme climate events was assuaged by his belief in reincarnation. Nevertheless, we emphasize that participants acknowledged that rejections of feelings of threat are not fully based on religious values. Moreover, religious coping or sense-making did not result in disclaiming climate change. Rather, participants acknowledged the effects of climate change but relied on their religious beliefs to reconcile their perceptions.

How livelihood resilience emerges through coping appraisal

Climate change adaptation measures are multifaceted. Some participants reported having taken tangible adaptation measures such as installing fans and planting more shade-giving plants and trees to counter extreme heat. Only very few participants could afford to install air conditioning. Some participants diversify income sources and cultivate food in the face of uncertainty, or shower more frequently to cope with discomfort. Kasun, a house manager, explains how he travels inland to visit his family and enjoy the more moderate temperatures during times of extreme heat. Farmers adapt by using natural methods, like redirecting water streams with mud, instead of costly technologies. Newly planted seeds often wash away in heavy unseasonal rainfall. Kosala, a tourist guide whose family owns a paddy field, explained:

> Some people use the method that we use, growing the seeds in a little place. We grow the seed to about three or four inches […] then when it comes to three or four inches, we get it and plant it […] it is good because it will protect the seeds from washing away.

Thus, some farmers shelter seedlings in protected areas to minimise crop loss. However, few farmers overall use this technique as it is labour- and cost-intensive. Moreover, while climate change directly affects agriculture, climate considerations don't always guide adaptation. Societal disruptions like the economic crisis take precedence.

The economic crisis, political unrest, and COVID-19 aftermath have collective implications. For many, economic survival becomes the priority, reducing the perceived urgency of climate change. For instance, fuel shortages affect the economic position of fishermen in Galle, as explained by a spokesperson from a local NGO:

> These two years people are suffering for that. […] Because they didn't have that experience previously because we were getting the unlimited facilities of fuel and those things. But nowadays it's too costly for them. The fishermen, they forgot their jobs because no fuel, they can't stay months and years in the sea, because they don't have that much fuel. The government is not issuing it.

The fuel crisis demarcates the space these individuals have to engage in adaptation strategies, as their livelihood depends on it. Additionally, many participants' lack of climate change education limits their knowledge of adaptation options, not to mention the frustration participants express when voicing the lack of government support. With solid climate legislation, residents might be given incentives or support to engage in structural adaptation strategies. As Kasun explains:

> Some people can make fuel with water, I heard, but I have never seen that […] Sri Lankan government doesn't allow, doesn't help […] they don't care about such things. […] We can use solar power for the vehicles. Also, we can use it for houses, but the government does not use solar power because they don't get commission in that way.

This leaves participants with no choice but to focus primarily on immediate necessities, even at the expense of their natural surroundings. This means that although participants report a high response efficacy in underscoring the necessity for structural climate change adaptation strategies, their self-efficacy is low, and response costs are too high to enact adaptive behaviour. Only a minority of participants demonstrated awareness of climate change when choosing to implement adaptation strategies as such. Nevertheless, current adaptation strategies primarily revolve around basic survival amid crises. Livelihood resilience thus hinges on coping appraisal; many participants reported wanting to engage in structural adaptation strategies, but lacking the means to do so.

Discussion

No individual or country is exempt from climate change. In what ways people decide to employ climate resilience strategies, however, depends on how and whether they perceive climate risks as threatening their livelihood. In turn, a variety of cognitive and identity-related facets influence people's attitudes and evaluations of climatic events. Employing an integrated framework encompassing well-established key approaches and theories, we analysed qualitative data collected through in-depth interviews and fieldwork diaries. This research explores the links between key notions, asserting a synthesis of these theories as the foundation of threat perception and livelihood resilience.

Rogers'[31] concepts of threat and coping appraisal explore how cognitive processes, demographic factors, identity, and context influence individuals' perception of climate risks. Although the PMT positions threat and coping appraisal as two parallel cognitive mechanisms unifying in self-protective behaviour, this research revealed a linear or sequential relationship. It was found that threat appraisal functions as a dimension of coping appraisal, thus affecting an individual's response and self-efficacy, response costs based on perceived severity and susceptibility of the climate risk, and maladaptive response reward. In essence, responsivity to the threat (i.e. outcome of coping appraisal) is partly contingent on the threat appraisal. Various indicators were reported as foundational to threat perception: Perceived vulnerability and threat severity were central in shaping it. Notable in framing these perceptions was the degree of knowledge individuals possessed about climate change and its impact on their financial stability. Generally, greater knowledge levels were associated with higher levels of stress. This resulted in a higher evaluation of a threat's seriousness and severity, aligning with the PMT. These greater knowledge levels often align with demographic factors such as age and education. The results suggest that first (familial) generation participants were generally less informed about climate change than younger individuals. This generally corresponded with low feelings of livelihood threat, often reinforced by the tendency to act according to each annual seasonal change instead of any sustained feelings of climate threats. Most (familial) first generation participants worked in weather or natural resource-dependent sectors such as agriculture or tourism, which involve planning for aspirations and climate strategies according to seasonal changes.

Findings showed a higher prevalence of climate change threat perceptions among younger participants, who often experienced more cognitive exposure to threats and risks through their education. Surprisingly, direct exposure or experience with climate-related events did not necessarily heighten perceived vulnerability and susceptibility. Although almost all participants recognized climate change through excessive rainfall in the dry season and temperature rise, extreme events such as the 2004 Indian Ocean

tsunami did not translate into perceived livelihood threats. Most participants recognized that tsunamis are an extremely rare event. Although some expressed trauma from their experiences, the repeated narrative of 'forgetting' reinforced their cognitive coping mechanisms, alongside the practical knowledge of the rarity of tsunamis. For some, (religious) beliefs and prioritization of other livelihood risks like weak socio-economic status added to the low threat perception of climate change risks. Still, we observed an exception to this low threat appraisal when individuals' financial security was directly tied to climate conditions or dependent on natural resources, as in the case of those working in the tourist and agricultural sectors. However, for many residents of Galle, financial stress was not solely contingent on unfortunate climate conditions but a result of various contextual factors including the country or region's current economic state, their job type, their education level, and the implementable resilience strategies at hand. Thus, when singling out climate risk perceptions whereby individuals feel threatened by climate change consequences specifically, most demonstrated a low perceived susceptibility to and severity of climate risks, and high maladaptive response rewards. This indicates low threat appraisal, ultimately resulting in a low threat perception, in line with the PMT.

Values, beliefs, and norms were also reported to influence threat perception, in line with the VBN theory. Environmentally conscious individuals valuing sustainability and environmental conservation were more concerned about climate change, a trait that strongly coincided with environmental knowledgeability. Sinhala participants with strong Buddhist values tended to exhibit lower threat appraisal. This could be attributed to these participants considering themselves to have an active role in climate change consequences, lowering their vulnerability to a (future) threat. Specifically, Buddhist principles emphasise acceptance of change (impermanence) and one's active role in the environment through the principle of *karma*. Some participants believed, to an extent, that dynamic altruistic behaviour would be rewarded with favourable livelihood conditions. In addition, a belief in reincarnation provided some participants with a certain reassurance of their resilience. This research, however, abstains from drawing strict conclusions based on individual religious beliefs, as these are generally subjectively interpreted and practised in personal ways. Nonetheless, the fact that participants often referred to their Buddhist beliefs and practices when discussing climate change implied the unequivocal importance of their beliefs in shaping threat perception.

Beyond the tools and resources that shape each individual's adaptive capacity, societal circumstances play a vital role in shaping adaptive behaviours and degrees of threat appraisal. A dearth of governmental incentives, financial aid, and knowledge of climate change in Galle aggravates the vulnerability of individuals whose livelihoods rely on natural resources or seasonal changes, who expressed being (physically and mentally) negatively affected by climate change, or who want to invest in climate-sustainable practices. The economic crisis further impedes adaptive capacity, highlighting the dependence of adaptive behaviours on external systems and contextual factors. In the terms of the PMT framework, individuals engage in coping behaviour when self- and response efficacy are high and response costs are low. Specifically, individuals with high levels of climate threat appraisal demonstrated a high response efficacy but low self-efficacy and considerable response costs. Participants who recognized the severity of, and their vulnerability to, climate risks (e.g., through their education, network, and self-study) and considered adaptive behaviour rewarding demonstrated adaptive responses, although constrained by their adaptive capacity. This means that most participants exhibited adaptive responses by putting adaptation techniques into practice using the resources they had at hand, however minimal, and believing them to be effective. These adaptive responses often manifested in tangible practical and financial security measures. Simultaneously, some participants who were aware of climate change risks lacked the financial capital to invest in structural adjustments and expressed the need for external support, such as government subsidies or support from NGOs or their social networks. Lack of resources was frequently mentioned as the most essential factor in limiting or preventing adaptive behaviour; this relates to a low level of self-efficacy and a low level of adaptive ability. Response costs are thus frequently too high, indicating that Galle residents are placed in a context of unfavourable adaptive circumstances.

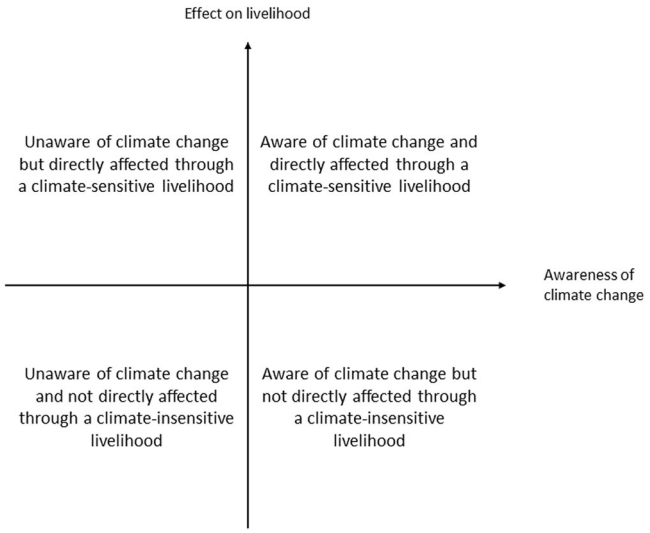

Fig. 2 | Climate change awareness and impact matrix. The matrix presents four quadrants with categories of individuals based on their perceived awareness of climate change (x-axis) and the direct effects on their livelihoods (y-axis). Following the increase in awareness and effect, four categories emerge: (i) Unaware of climate change and not directly affected by a climate-insensitive livelihood. Participants in this category demonstrated little knowledge of climate change and were not economically dependent on climatic circumstances or natural resources; (ii) Aware of climate change but not directly affected by climate-insensitive livelihood. Participants in this category demonstrated a relatively high to high knowledge of climate change but were not economically dependent on climatic circumstances or natural resources; (iii) Unaware of climate change but directly affected by a climate-sensitive livelihood. Participants in this category demonstrated little to no knowledge of climate change, although economically dependent on climatic circumstances or natural resources; and (iv) Aware of climate change and directly affected by a climate-sensitive livelihood. Participants in this category demonstrated a relatively high to high knowledge of climate change and are economically dependent on climatic circumstances or natural resources. Each factor and their intertwinement underlie the extent to which participants engage in adaptation strategies.

Four categories of individuals emerged based on their perceived awareness of climate change impacts and the direct effects on livelihoods (see Fig. 2). Evidently, in our contemporary globalized world, everyone is to some extent affected by climate change. It should thus be emphasized that "not directly affected" means that the participant does not depend completely on climate-sensitive factors to secure their livelihood and basic necessities. Climate-insensitive livelihoods do not hinge on employment within natural resource- or weather-dependent sectors, and do not secure access to water, food, and shelter through a first-hand dependency on natural resources. Individuals in these four categories demonstrated various degrees of perceived climate risk severity, susceptibility, and adaptive capacity based on their education, employment, and values.

Livelihoods directly impact the extent to which participants are aware of and affected by climate change and risks. Participants whose livelihoods rely on natural resources or seasonal changes and who were educated on climate change expressed higher awareness of climate change risks to their livelihoods (upper right quadrant, Fig. 2). Consequently, they are more likely to engage in adaptation strategies than individuals positioned in one of the other categories. Yet, the relationship between awareness and adaptation is not always straightforward. Participants whose livelihoods did not directly rely upon natural resources or weather conditions, but expressed an awareness of climate change often exhibited low adaptive responses despite their awareness of climate change (lower right quadrant). Participants who were both unaware and not directly affected by climate change exhibited

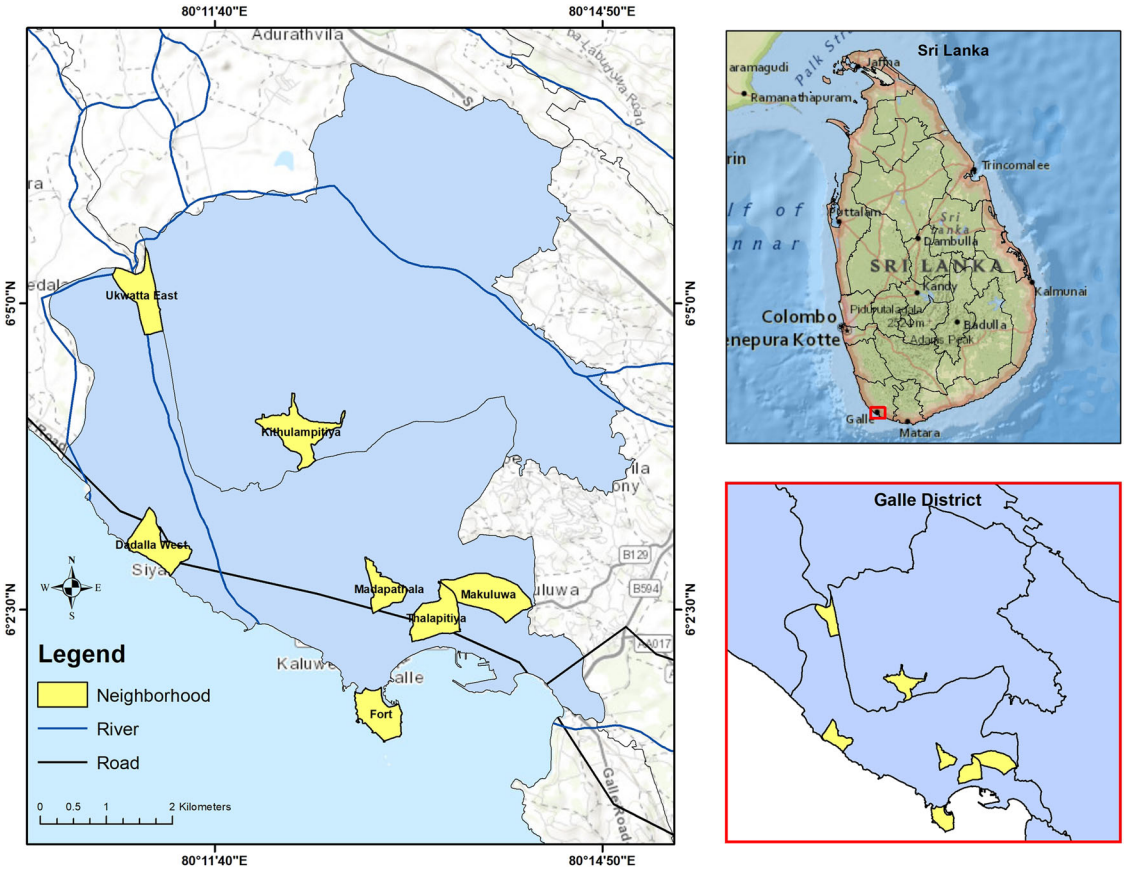

Fig. 3 | Study area map. The study area map specifies in which divisional secretariats (Ukwatta East, Kithulampitiya, Madapathala, Makulua, Fort, Dadalla West, Thalapitya) data was collected, either through in-depth semi-structured interviews, participant observation or small talk. The locations emerged through snowball and convenience sampling. Source: author's illustration.

similarly low responsivity (lower left quadrant), such as was expressed by a primary school teacher who had never heard of the term. Participants who self-identified as having strong financial capital and resilience to the economic crisis through their employment or kinship network also expressed low adaptive behaviours. This underscores the role of contextual factors such as economic stability in shaping adaptive behaviour. Moreover, an unawareness of climate change conditions did not necessarily result in maladaptive behaviour. Often, participants implemented practical measures to counter bodily discomforts and livelihood stress due to rising temperatures without specific knowledge of climate change (upper left quadrant, Fig. 2). Adaptations are thus seldom carried out solely in reaction to the effects of climate change[29].

Adaptive behaviour is influenced by a complex web of societal circumstances and individual cognitive and responsive processes that shape threat perception. A comprehensive understanding requires consideration of threat perceptions and the capabilities and systemic dynamics that enable or constrain adaptive behaviours. Our analytical framework expands to encompass adaptive capacity, assets, and capabilities influenced by vulnerability and exposure, providing a more holistic and intersectional perspective on why some individuals can or choose to engage in resilience strategies and others do not[30]. This research acknowledges the nuanced nature of individual perceptions and adaptive behaviours. While drawing on established theories and approaches, the findings emphasize the unique context of Galle. The focus on individual livelihood resilience underscores how the broader societal and economic contexts shape and facilitate adaptive behaviour within the range of adaptation possibilities. Ultimately, although threat perception emerges as a key incentive for implementing climate adaptation strategies, its manifestations are thus highly intricate, individual-specific, and context-dependent.

Methods

Study area

We conducted fieldwork for this study in seven neighbourhoods in the coastal city and divisional secretariat (D.S. division) of Galle, on Sri Lanka's southwest coast (see Fig. 3). Galle is the administrative centre of the Galle District and the largest city in the Southern Province. Positioned 116 kilometres south of Colombo, Sri Lanka's capital city, at the time of its last census Galle had a population of 101.159[37]. Its coastal location, with various rivers flowing through the city, in combination with an absence of coastal flood protection, exacerbates the impact of heavy rainfall, making Galle vulnerable to various climate risks. Positioned in a wet zone, it has a tropical rainforest climate and is prone to heavy rainfall during the *Yala* monsoon season (corresponding to the southwest monsoon from May to August), leading to environmental risks such as riverine and flash floods[1,38]. At the same time, Galle has a network of important roads adjacent to the coast, with no place for overflow areas or floodplains. Moreover, inadequate drainage and poorly constructed buildings increase Galle's vulnerability to rapid-onset events, as happened during the 2004 Indian Ocean tsunami following the Sumatra-Andaman earthquake in Indonesia, one of the deadliest natural disasters on record[39]. Galle was severely affected, with a death toll of 500 people, 90 more missing, and damage to almost 3000 houses and other buildings; a greater impact than that felt by its neighbouring coastal districts Matara and Kalutara[39]. This devastating event exposed Sri Lanka's coastal residents' extreme vulnerability[7].

Considering its geography and topography, climate, fragile infrastructure, and exposure to climate risks, we posit that Galle lies in an environmental risk zone. Without appropriate adaptative action, the expected rise in the frequency and intensity of climate change-induced extreme weather events might endanger lives, livelihoods, and

infrastructure[1], making further research on resilience strategies in Galle is crucial.

Data collection and analysis

We chose qualitative interviews, namely semi-structured in-depth interviews, as the main method for data collection due to their alignment with the subjective nature of perceptions, experiences, and strategies. Predefined topics and central questions guided the interviews while providing the flexibility to explore subjects and issues raised by the participants[40]. An interview guide was created before fieldwork. To ensure rigour and validity, we designed the predetermined questions based on the variables established in the analytical framework (see Fig. 1). We identified participants through snowball and convenience sampling[40]. The sample includes 30 semi-structured in-depth interviews with Galle residents.

Lastly, participant observation and small talk emerged as crucial methods during fieldwork. We conducted participant observation mainly around participants' home and work bases. Sites included souvenir shops, restaurants, paddy fields, the back of a tuk-tuk, and hotels. Both methods facilitated the eliciting of essential data. Developing and sustaining positive connections with interlocutors significantly contributed to the effectiveness of the fieldwork[40,41]. Data analysis comprised manual coding of transcribed recordings and fieldwork diary entries through inductive and deductive coding.

Data availability

The data that supports the findings of this study are available from the corresponding authors upon reasonable request.

Code availability

The codes that support the findings of this study are available from the corresponding authors upon reasonable request.

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Author contributions

Conceptualization, J.B. & B.M.; data collection, J.B.; review and analysis, J.B. & B.M.; results & discussion, J.B.; writing drafts, J.B.; copy-editing and revision, B.M.; finalizing, J.B. & B.M.

Competing interests

The authors declare no competing interests. However, JB has collected the data used in the context of her master’s thesis project for the partial fulfilment of her master’s in International Development Studies at Utrecht University, The Netherlands.

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