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USING A SYSTEMS THINKING APPROACH TO INCREASE COASTAL COMMUNITY RESILIENCE AGAINST ENVIRONMENTAL SHOCKS: A CASE STUDY OF VALIATHURA COASTAL AREA, INDIA

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ABSTRACT

Aim of the study
Globally, the increasing environmental shocks in coastal zones of tropical regions are crippling human-ecological systems' interactions that promote sustainable development. The uni-dimensional nature of environmental shocks is increasing the environmental vulnerabilities of coastal people who heavily depend on marine and environmental resources. Current policies on resilience are mainly linear thus negating coastal communities' ability to develop synergies for adaptation and mitigation.

Material and methods
We used the Iceberg model of systems thinking to identify local system dynamics in relation to vulnerability to environmental shocks and the 3 Horizons framework to qualitatively identify the preferred options that can lead to a preferred future involving avenues for increasing women's resilience to environmental shocks in coastal areas, using Valiathura in Kerala as a case study.

Results and conclusions
We developed a novel Three Horizon (3H) framework that links current system indicators in Valiathura, which could be used to understand environmental shocks and how to navigate through such shocks. Based on the developed framework, we identified possible pathways in Valiathura that can be used by coastal people and regions in other jurisdictions to promote sustainable change from Horizon 1, and 2 to Horizon 3 such as increasing women's knowledge of environmental shocks and leveraging the historical strategies used by coastal women to increase resilience against environmental shocks. Therefore, to develop sustainable actions in coastal zones affected by environmental shocks, a focus on understanding the dynamics of the system is key to understanding system interactions and feedback that can inform actions, which promote transformative change, for instance, related to adaptation and mitigation.

Keywords: system thinking, environmental shocks, coastal community resilience, novel Three Horizon framework, Valiathura – India

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INTRODUCTION

The exponential distortion of ecological subsystems in the current Anthropocene era is catastrophically threatening the provision of marine ecosystem services and goods due to the breakdown of feedback mechanisms availed by the marine ecosystems (Achberger, 2015; Albert, 2016); thus increasing the cost of environmental disasters on the global economy and livelihoods (Matovu et al., 2023). For instance, in 2020, environmental disasters exacerbated by climate change alone led to a loss of 232 billion USD to mitigate and adapt to the effects of natural disasters (ADB/UN, 2018), a 26 percent increase compared to 2019 (AON, 2019). And the total cost of environmental disasters has sprawled to about 3 trillion USD since 2000 (Alexander, 2006; ADB/UN, 2018). A spatial analysis of environmental disasters documents increasing coastal damage mainly due to four leading global disasters (floods, severe weather, tropical cyclones, and earthquakes) and these are prevalent in the tropics e.g. in India, especially along her open coastlands (WOA II, 2021; GoK, 2018; ADB/UN, 2018). In fact, the World Bank's Gender Dimensions of Disaster Risk and Resilience Report (2018) reveals that the total cost of environmental disasters in the last 15 years has skyrocketed to 3 trillion USD, and total damages have ballooned by 600 percent, especially for marginalized groups and women due to structural barriers to mitigate and adapt to environmental shocks (GoK, 2017; ADB/UN, 2018). This wicked paradox is ruining the livelihoods of communities that are heavily dependent on the environment or nature for survival (Jaishankar, 2018; Matovu and Raimy, 2022), and hence the need for feasible and resilient infrastructure and systems to mainstream environmental risk management and development of socially inclusive societies to boost disaster response (Fazey et al., 2016; Maneesha et al., 2023). In fact, it is projected that inclusive social mechanisms and systems could reduce the losses from environmental shocks by 31 percent (Burns and Worsley, 2015).

India is highly vulnerable to environmental disasters partly due to its geography astride the equator, Indian Ocean Dipole (IOD), and the El-Nino/Southern Oscillation (ENSO) zone; which grossly scavenge into the fragile coastal socio-economic livelihoods and natural coastal systems (Cornell et al., 2013; AON, 2019; Guntha et al., 2020). Since 2000, India has cumulatively lost about 80-100 billion USD (Chopra, 2016; ADB/UN, 2018), partly due to the increasing magnitude and frequency of environmental shocks and disasters (IRP, 2021). In 2019, the monsoon floods in India led to an economic downturn of 10 billion USD with 1750 human fatalities, which made it the leading global human fatality event of 2019! (AON, 2019). The unsustainable environmental and livelihood costs due to increasing natural disasters in India call for the development of robust systems to mitigate the socio-economic losses emanating from such catastrophes, and to create sustainable futures (Curry and Hodgson, 2008; Chandler, 2013; Lukambagire et al., 2020).

In Kerala, about 15 percent of the coastland is flood-prone; increasing the vulnerability to over 18,700 households living along the shore-land and coastal fringes (Albert, 2016; ADB/UN; 2018; Matovu et al., 2023). Since the 1970s, Kerala has experienced 65 deadly slides emanating from the Western Ghats, and the 2004 deadly Tsunami (Irshad, 2013). The increasing frequency and magnitude of environmental disasters, risks, and hazards such as landslides, ocean storms, floods and annual double monsoon winds in Kerala have decimated socioeconomic structures such as farmlands and fish stalls along coastal regions and natural resources used by poor people and women to sustain their livelihoods (Pavithran et al., 2014; Chopra, 2016; GoK, 2018; KSDMA, 2018; Maneesha et al., 2023). Even though some studies have reported that the level of effect and resilience to environmental shocks in Kerala is relative in a given social system or coastal zone, there is a need to identify complex values, systems, and events that escalate and/or deescalate vulnerability to environmental disasters (Burns and Worsley, 2015), and systems' behavioral parts to build new and comprehensive functional structures that create fairly desirable sustainable futures, especially among coastal communities as advocated for by global frameworks and policies e.g. the United Nations Decade of Ocean Science for Sustainable Development (2021–2030) (Fazey et al., 2011, 2016; IOC-UNESCO, 2020).

The main assumption of the present study is as follows: though environmental shocks are inevitable natural events, the effect of such events and the level of

resilience/devastation in a given coastal system varies and highly depends on a systematic historical pattern in a local system, existing structures, and infrastructure that limits/favors resilience, and the mental/cognitive mindset towards a given people or community. In other words, the effects of a given environmental shock and the ability to be more resilient or adaptive to such shocks depend on how a given community understands the systems dynamics that lead to such shocks. Higher level of understanding of such systems reduces the impact, whereas lower level of the understanding of system dynamics increases the negative externalities from a continuation of the environmental shocks. Therefore, in the context of vulnerable coastal zones e.g. in Kerala, we argue that the complex socioeconomic conundrum could be a catalyst for increasing/decreasing micro-level and meso-level vulnerabilities of coastal communities, necessitating the need to develop local and community-based systems/frameworks to map out pathways for sustainable futures (Fazey et al., 2016; WOA II, 2021). However, most system dynamics studies document that there is hardly a holistic approach to understanding or developing mechanisms that promote resilience to environmental shocks (IOC-UNESCO, 2020; IRP, 2021; WOA II, 2021; Matovu et al., 2023). Thus, this study aims to use the Iceberg model and 3 Horizon's model to show avenues for environmental resilience to increase coastal communities' resilience to environmental shocks, using a case study of Valiathura in Kerala, India. To achieve this, the study is guided by three research questions: (1) what are the main environmental shocks in the Valiathura coastal area in Kerala? (2) What is the level of communities' – and especially women's – resilience to environmental shocks in the Valiathura coastal area in Kerala? (3) Do current strategies promote communities' resilience to environmental shocks in the Valiathura coastal area in Kerala? And how can we navigate through this complexity by using the systems models to fit into local dynamics in Valiathura?

STUDY AREA: VALIATHURA COASTAL AREA PROFILE

Valiathura is a small coastal fishing village located in the Thiruvananthapuram Corporation in Kerala state (see: Figure 1) (Krishna, 2017). Valiathura covers half of Ward 80 in Thiruvananthapuram district (Shyam et al., 2017; GoK, 2018). Kerala state environmental statistics highlight that Valiathura is highly prone to environmental shocks such as monsoon storm surges, coastal erosion, sea level rising, seasonal drought, landslides, and tsunamis (ADB/UN, 2018). About 13 percent of Valiathura is flood-prone, and areas close to the Western Ghats are prone to landslides (Jaishankar, 2018). Valiathura's proximity to the Arabian Sea and its location in a Tsunami prone zone increases the risk of Tsunami waves that devastated Kerala in 2004 (Krishna, 2017; Shyam et al., 2017). Demographic statistics show that 51 percent of the 1800 households in Valiathura are vulnerable to storm surges and monsoon as they live in *pucca*, semi-*pucca*, and *kachha* houses (Pavithran et al., 2014). Valiathura coastland is open and unsheltered from ocean waves, and the area has 1 seawall. Only 5 percent of fishing vessels are mechanized, and most local people are not insured with the Matsya board (GoK, 2018). Thiruvananthapuram and Valiathura have the highest Female Scheduled Caste Population in Kerala at 52 percent, and formal women employment is low: estimated at 34 percent (GoK, 2017).

METHODS AND MATERIALS USED

The study used the Iceberg model of systems thinking to identify how current local systems lead to structural gaps that increase vulnerability to environmental shocks/events (Curry and Hodgson, 2008; Fazey et al., 2016), as well as the three horizons (3H) framework to identify pathways towards increasing vulnerable communities' resilience to environmental shocks (Gallopín, 2006). This is meant to develop a simple and novel framework for structured and guided dialogue amongst different community actors that would link different patterns of transformative change by using examples in a local setting under study, and identifying positive leverage changes to increase the ability of coastal people and the coastal area dynamics in general to adapt and cope with environmental shocks (Folke, 2006; Folke et al., 2010). To identify the system dynamics forces related, among other things, to environmental shocks, and specific to the social system in Valiathura, our initial strategy was to conduct a non-systematic literature

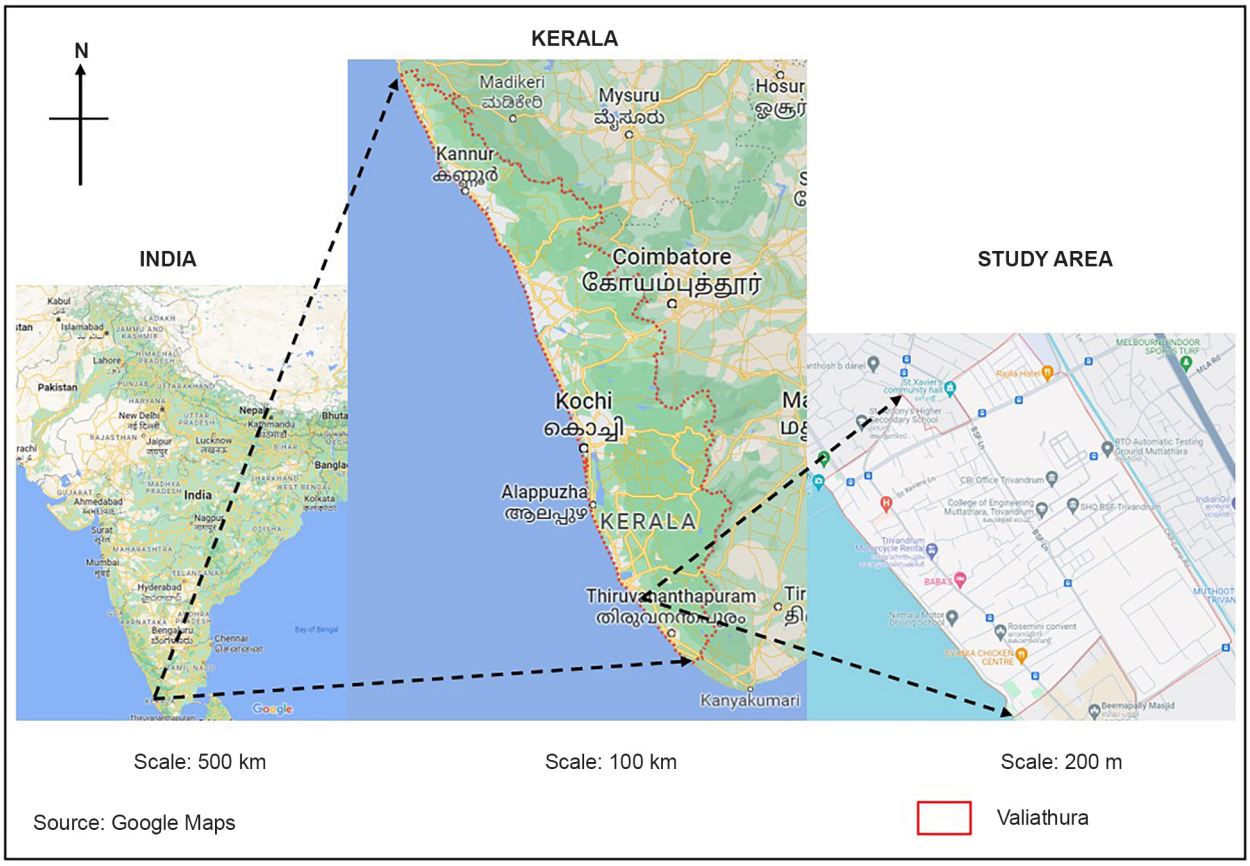

Fig. 1. Map of Valiathura (source: Google maps)

review to identify (i) the main environmental phenomena e.g. floods in Valiathura; (ii) demographics of the area; and (iii) how such human-environmental systems interact to either increase or decrease vulnerability. We reviewed 25 documents (mainly reports and published articles in coastal Kerala accessed via Science Direct and Google Scholar) to develop our model (see: Figure 2).

How the Iceberg model was used to develop a 3 Horizon Framework

The iceberg model was used to identify four levels of increasing/decreasing vulnerability to environmental shocks in Valiathura. These levels are:

Event level – in our study, this level denotes how the complex environmental disasters in Valiathura are managed by using temporary and simple solutions (Escalating Horizon 1).

Pattern level – this shows the sequence of occurrence of environmental disasters such as floods over time, and how society has been mitigating the effects of such environmental shocks (Horizon 2).

Structure level – this highlights the existing sociocultural structures, governance organization, and policies in Valiathura, and how they increase vulnerability. For instance, at this level we look the social structure or system and its impact on the resilience of vulnerable/marginalized communities – marginalized coastal fisherwomen being an example of one such group.

Mental model level – this involves the understating of the local people's attitudes and beliefs (psychological domain), and how they continuously influence resilience/vulnerability to environmental shocks such as social stereotypes and discrimination.

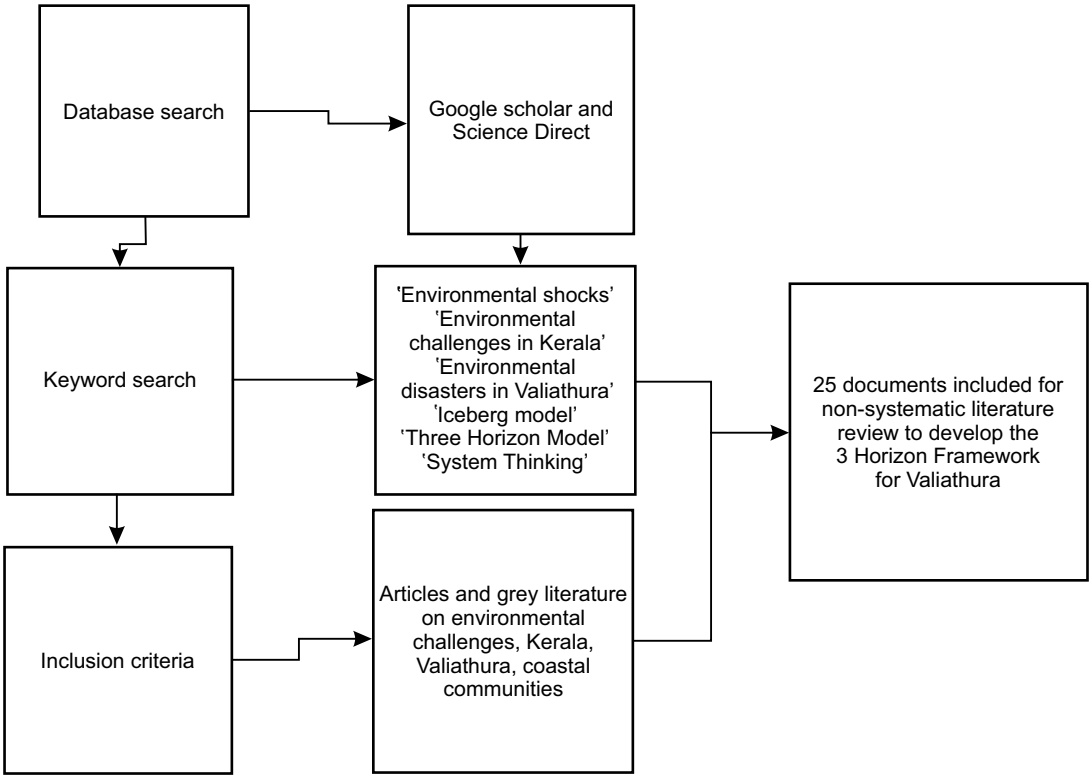

Fig. 2. Flowchart for literature inclusion (source: elaborated by the Authors)

Development of the initial steps to develop the 3H Framework

The Iceberg model levels and the nature of environmental shocks in Valiathura extracted from the sourced documents were integrated into Table 1. This is done to create baseline indicators that relate to the Iceberg model levels to be integrated into the 3 Horizon Model, in order to chart out a pathway that can yield transformative change in Valiathura by tapping the known understanding or knowledge of Valiathura system dynamics and interactions into the environmental shock management framework.

Key findings for the 3H Framework development

Complex social systems in Valiathura increasing communities' vulnerability to environmental shocks

Findings from the literature documented the complex nature of environmental shocks and the negative effect on livelihoods in Valiathura, and these increase the need to design frameworks that link the environmental and socioeconomic understanding of the interrelated systems to identify leverage points at various scales – that would engage the various groups of people and local institutions to promote transformational change and minimize competing values and threats to both livelihoods and ecosystems (Barsh and Yee, 2012; Sharpe et al., 2016; IRP, 2021). This could be achieved through innovations and inventions to build resilience into current and uncertain future exposure (Waddock et al., 2015; OECD, 2016). A review of environmental risk management frameworks in Kerala and Valiathura highlights that though strategies have been earmarked to identify and manage environmental shocks, complexities exist in merging multiple perspectives and integrating the values and norms of local vulnerable groups such as women, and poor coastal people (Barsh and Yee, 2012). This creates a limited understanding of how to develop interventions in the system both currently and in the future (Folke et al., 2010). The development of a clear pathway/frame-

Table 1. The nature and level of exposure to climate and geophysical environmental shocks in Valiathura (developed by the Authors, source: Goswami, 2007; Pavithran et al., 2014; ADB/UN, 2018)

Environmental Shock	Exposure time frame	Description of the environmental shock and the effect on livelihood in Valiathura
Extreme Temperature	Current	Increasing coastal temperatures due to global warming and ocean warming lead to the drying out of mangrove swamps used by local women to harvest mangroves for making crafts, and affect planting seasons.
Extreme monsoon rainfall	Current	Valiathura increasingly experiencing flash monsoon rainfall affecting fish farms, uncertainty on upwelling, and destroying crops. 51% of 1800 households are vulnerable.
Coastal flooding	Current	Coastal Valiathura is generally flat, with heavy rains, sea level rise, and tides destroying coastal settlements and infrastructure. They destroy settlements and supporting infrastructure. Over 1000 *puccas*, *kachha* houses vulnerable.
Drought	Future	Increasing temperatures have led to changing rainfall patterns, and increasing aridity – hence water shortage, food insecurity, and the emergence of hard coastal soil pans.
Sea level rise	Current	The Arabian Sea level is rising due to changes in global ocean pressure and circulation affecting coastal infrastructure.
Storm surges and typhoons	Current	The magnitude and frequency of coastal storms is increasingly affecting local fishery, settlements, and development infrastructure.
Tsunami	Future	Since the 2004 Kerala Tsunami, local communities have lived in fear of a future sudden occurrence of another Tsunami affecting the setting up of permanent infrastructure.
Strong monsoon winds	Current	The increasing frequency and magnitude of monsoon winds destroy socioeconomic infrastructure used to promote livelihoods.
Earthquakes	Future	Proximity to the Arabian and Indian Ocean plates is projected to destroy coastal infrastructure and is likely to trigger destructive ocean waves.
Landslides	Current	Increased human activity along the Western Ghats cause and exacerbate mudslides and rock falls that destroy human settlements and farmlands.

work to make well-informed decisions, draw interrelationships, and connect agencies (feasible decisions, choices, capacities, and capabilities of each group) is essential (Achberger, 2015). Our study contributes to this, first, by mapping out the current system dynamics to gain an understanding of both the visible and the invisible interactions that are likely to proliferate vulnerabilities based on the Iceberg model (see: Figure 3). This formed the basis to design a futuristic scenario based on the 3H framework on how the local system could navigate through this complexity (as shown in Figure 5 and Figure 6).

Use of the Three Horizon's (3Hs) pathway to promote women's resilience to environmental shocks in Valiathura

Figure 3 mapped some complex systems/patterns/events that are increasing vulnerability to environmental shocks in Valiathura using the Iceberg model. In Figure 3, at each level, we clearly identify the main environmental shocks that are reported (in literature) to be key in increasing vulnerability to environmental shocks. The understanding of such a system helps in unlocking barriers and mapping of possibilities for balancing a fragile system (Achberger, 2015).

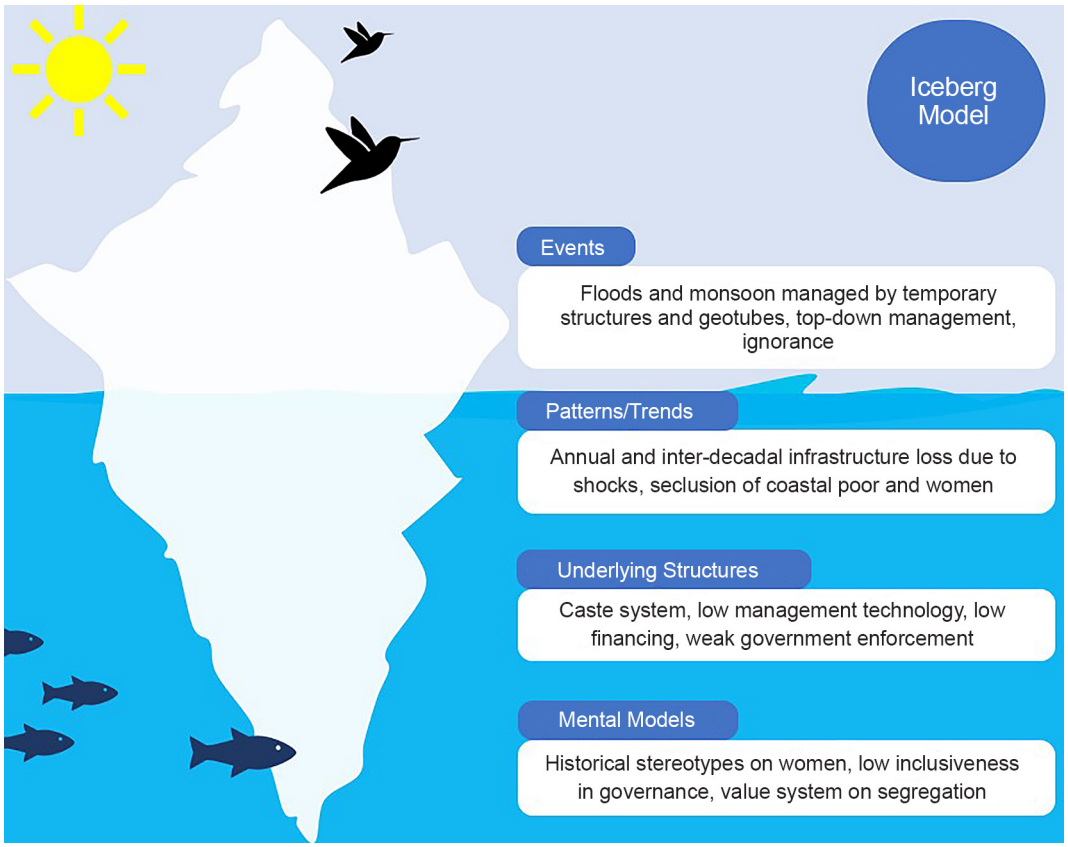

Fig. 3. Iceberg model for Valiathura indicating local vulnerabilities (source: elaborated by the Authors)

Incorporation of the Systemic risks featured in Figure 3 into the 3H Framework

The 3H pathway has increasingly emerged as a new paradigm in promoting socioeconomic transformative change based on the understanding of the values and perspectives of community actors, and designing of innovative solutions to long-term community pressures that strain community livelihoods (Curry and Hodgson, 2008; Arkesteijn et al., 2015). A study in Glasgow on climate change and community action by the International Futures Forum using the 3H model facilitated the understanding of community horizons in the form of conscious perspectives and led to the initiation of practical research that guided the deployment of human effort, finance, and climate resilience resources (Folke, 2006; Burns, 2007; Burns and Worsley, 2015). The 3Hs has also been used to connect community components that lead to weak livelihood systems through integrating existing knowledge material with existing social systems to develop future scenarios through strategic visioning of actions that promote social transformative change (Folke et al., 2010; Câmpeanu and Fazey, 2014; Sharpe et al., 2016). Similarly, the 3Hs pathway can be used in Valiathura to identify stakeholders and actors directly and indirectly affected by environmental shocks and create relationships/conservations on the driving forces behind such shocks and the inability to fully adapt or cope with such shocks and this could be through workshops with vulnerable women groups and people (Alexander, 2006; Gallopín, 2006).

In our study, we have done this through the extraction of literature to create a 3Hs diagrammatical framework comprising of 3 horizons (H1, H2, and H3) (see: Figure 4) (Curry and Hodgson, 2008; Ison et al., 2014). Each Horizon shows how local actors in Valiathura operate and relate to the environmental shocks both during stress and no-stress conditions; gendered

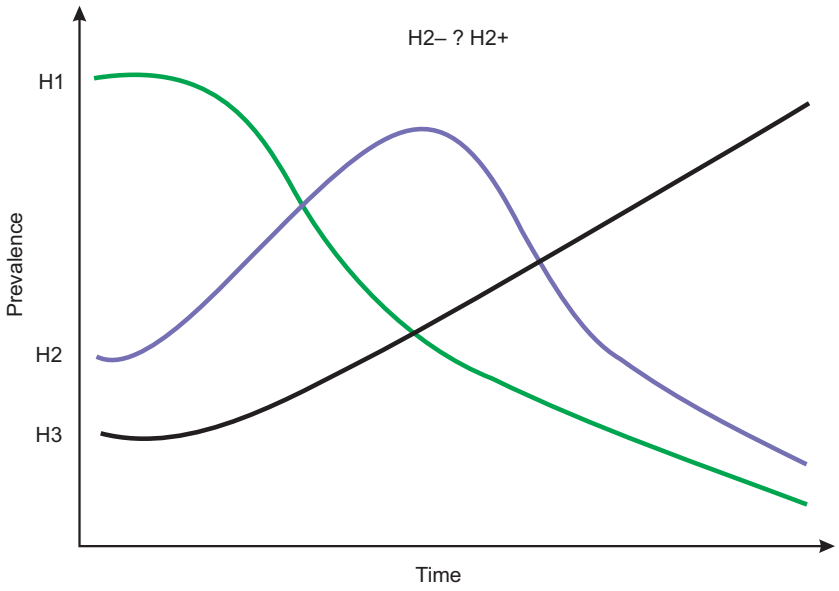

Fig. 4. 3H Pathway on how a community's level of resilience varies over time and prevalence (source: elaborated by the Authors)

values in the Valiathura society; or the use of certain forms of technology to manage environmental shocks. Accordingly, the level of vulnerability depends on the prevalence of a given environmental shock over time, and this can change/vary depending on how a given community adopts new technologies or bridges socioeconomic, political, or institutional gaps that make some local people more susceptible to a given environmental shock.

The horizontal axis of the 3Hs pathway is denoted with time representing the desired future from the present situation. In Valiathura, the desired future is increasing resilience to environmental shocks (Miller, 2010). The vertical axis shows the prevalence of each horizon pattern via transitions that take place over time (Curry and Hodgson, 2008; Arkesteijn et al., 2015). Prevalence thus will represent the rate at which a particular pattern in Valiathura dominates resilience to environmental shocks (Sharpe et al., 2016).

H1 represents the business-as-usual situation (Curry and Hodgson, 2008; Sharpe et al., 2016); demonstrated by increasing vulnerability to environmental shocks in Valiathura and the existing socioeconomic and governance systems, which partly reinforce or reproduce such vulnerabilities over time (Sharpe et al., 2016). For example, fragmented governance systems and a delay in setting up sustainable environmental disaster management systems increase the effect of environmental shocks (Leach, 2008). *H1* shows the current declining ability of local communities and women in Valiathura to build up resilience against increasing environmental shocks.

H2 represents a turbulent period dotted with the innovations and current practices that local people and women in Valiathura are trying to apply, in order to transition and become resilient to environmental shocks considering their current level of resilience/vulnerability to environmental shocks and their future aspirations (H1 and H2) (Burns, 2007; Sharpe et al., 2016). In this pattern, some innovations (H2+) will yield positive results to facilitate H3, and some innovations might fail to achieve the desired future (H2-); and these will escalate H1 (Burns and Worsley, 2015).

H3 represents the long-term desired future of the area or a system, such as in Valiathura, as a response to *H1* and *H2* (Curry and Hodgson, 2008; Burns and Worsley, 2015).

To map the best possible desired future for community resilience to environmental shocks in Valiathura, forecasting tools using modern prediction approaches focusing on the complex nature of a system's agency, domain, and level of uncertainty in a system's life cycle are crucial (Curry and Hodgson, 2008). These

involve an understanding of the (i) systems resources that are exploited; (ii) level of conservation; (iii) the release phase that creates instability in the system due to an external disturbance and shocks; and (iv) reorganization of a system to enable recovery from a given external shock, using roadmaps to link social systems' complexities and approaches to map the links and desired future scenarios (Leach, 2008; Burns and Worsley, 2015). In our study, we mapped all the targeted or desirable resilience and adaptation measures and pathways as obtained in the sourced literature to create the preferred system lifecycle that could be key to reducing environmental shocks, amalgamating all the system forces, agency, and links (Folke et al., 2010; Burns and Worsley, 2015) (see: Figure 5).

The schematic illustration in Figure 5 shows that in Valiathura, depending on the application of a given intervention/leverage point, some approaches can work well at some level of uncertainty and agency domain, and most pathways can be related/are interlinked to existing roadmaps therein. Similarly in Valiathura, some scenario could be more effective when there is a high level of uncertainty and thus roadmaps can help identify the most feasible directions for transformational change to promote resilience to environmental shocks by different actors including, local institutions and groups, such as *Panchayats* and *Taluk* and women (Arkesteijn et al., 2015; GoK, 2018). Thus, based on the existing literature in Valiathura and Kerala, system interventions in place and roadmaps could work well in promoting community resilience where the level of agency is high, and where the actors are able to manage the uncertainty (Waddock et al., 2015). Due to the variations in the level of uncertainty in the local system – for instance, as to socioeconomic changes in Kerala – the scenario can work well where the level of uncertainty is high with relatively low degrees of agency, to act as an input for the strategy process in creating a desired future level of resilience among vulnerable coastal users, for instance, the fisherwomen (Sathiadas et al., 2004; Burns, 2007).

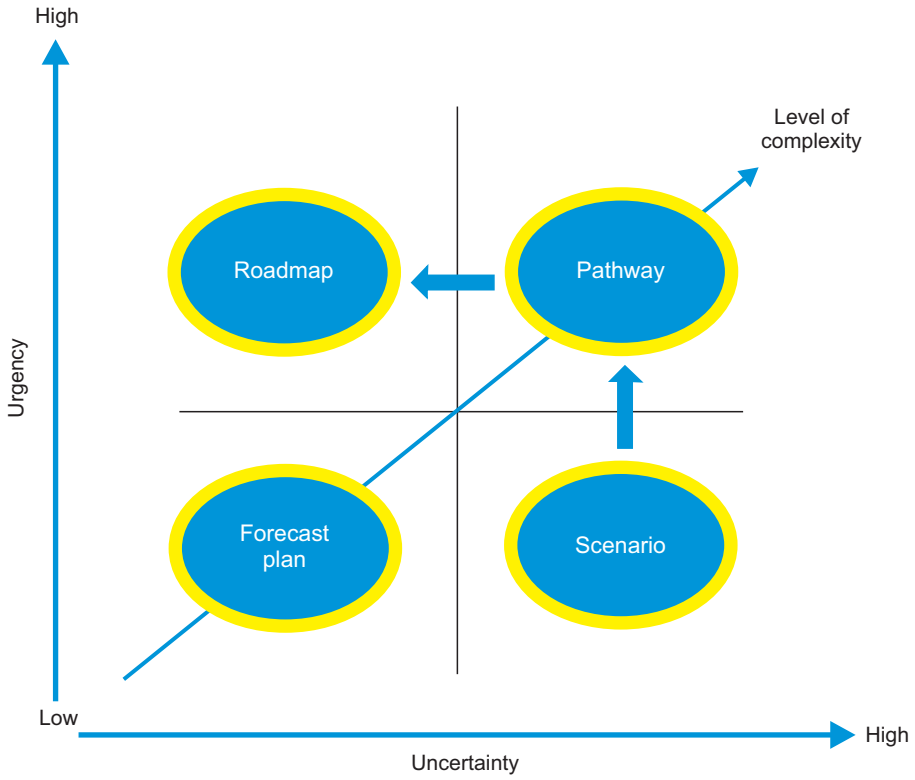

Fig. 5. System lifecycle for resilience and adaptation to environmental shocks (source: elaborated by the Authors)

Developed 3H Model that can increase community resilience to environmental shocks in Valiathura

Our developed framework integrates different scenarios based on the level of prevalence of environmental shocks, and preferred timeline for system change. To understand the level of prevalence of a given environmental shock (see: Table 1), we created 3 Horizons (H1, H2, H3). For each horizon, we indicated the current environmental concerns, existing innovations and interventions to reduce the concerns and the desired future targets to adapt and mitigate environmental concerns (see: Figure 4).

For each phased component of the system change/horizon, we mapped out both positive and negative system identifiers that either escalate or de-escalate environmental concerns, particularly in the current system of Valiathura. This is meant to create best options required for transition for positive change so as to develop locally feasible opportunities for the desired future, where local communities are more resilient or adaptive to environmental shocks.

Interpretation and explanation of the applicability of the 3Hs pathway in Valiathura

The application of the 3Hs pathway in Valiathura can be comprehended through a cyclic process involving a set of five stages:

(i) **Examination of the current environmental shocks** in Valiathura and how current practice is increasing vulnerability. For instance, Valiathura harbor construction is escalating coastal erosion by breaking waters/wave backwash, and this threatens makeshift tents used by women and local people to sell fish and market their produce (Albert, 2016; GoK, 2018). This requires a review in developing inclusive systems to include local fisherfolk, including fisherwomen, of Valiathura in coastal management (Leach, 2008).

(ii) **Exploring future aspirations of local people in Valiathura.** This relates to the identification of what local people seek to achieve in the future *(H3*) to reduce the effects of environmental shocks and current vulnerabilities in *H1*(Miller, 2010). For instance, this would involve setting up of local state policy for coastal protection through a local environmental management model, and encouragement of local leadership autonomy (Alexander, 2006). This will make local women and coastal people own up to the need for sustainable management and protection of the coast amidst them (Ison et al., 2014).

(iii) **Exploring of the existing inspirational practices in Valiathura.** This relates to identifying future-oriented and sustainable practices in the present routines followed in Valiathura for reducing environmental shocks (Sharpe et al., 2016). For instance, local women's training and the use of cultural/historical knowledge development for coastal management through training, the use of historical groynes and temporary geo-tubes filled with sand to create sea walls to reduce the effect of the swash and backwash, and women's planting mangroves in open coastal zones (KSDMA, 2018). This can create transition change for integrated coastal management in H2 and H3 (Curry and Hodgson, 2008).

(iv) **Innovations in play in Valiathura.** These innovations focus on the current practices to increase resilience to environmental shocks, namely, mitigation strategies, which are temporary in nature (Waddock et al., 2015). Examples might include local authorities and local communities setting up temporary structures such as geo-tubes to create artificial sand banks that can reduce wave strength. Women who are skilled in making artificial bamboo reefs and organic sand fencing could be employed to create coastal defenses and reduce coastal destruction (GoK, 2017). These can help in transitioning from *H1* to *H3* (Fazey et al., 2016).

(v) **Identification of crucial and sustainable aspects to maintain.** This step focuses on using feasible and sustainable aspects that help increase resilience to environmental shocks (OECD, 2016) – for instance, in Valiathura. These are the aspects in *H2* that reduce/increase environmental shocks in H1 and how coastal community practices can lead to a transition to *H3* (Waddock et al., 2015; Fazey et al., 2016). For example, coastal dredging and harbor construction is escalating erosion in unconstructed coastlands of Valiathura, and this creates environmental dilemmas in *H2* (Burns, 2007; Pavithran et al., 2014). To transition from this business as usual scenario, training for the local community, including

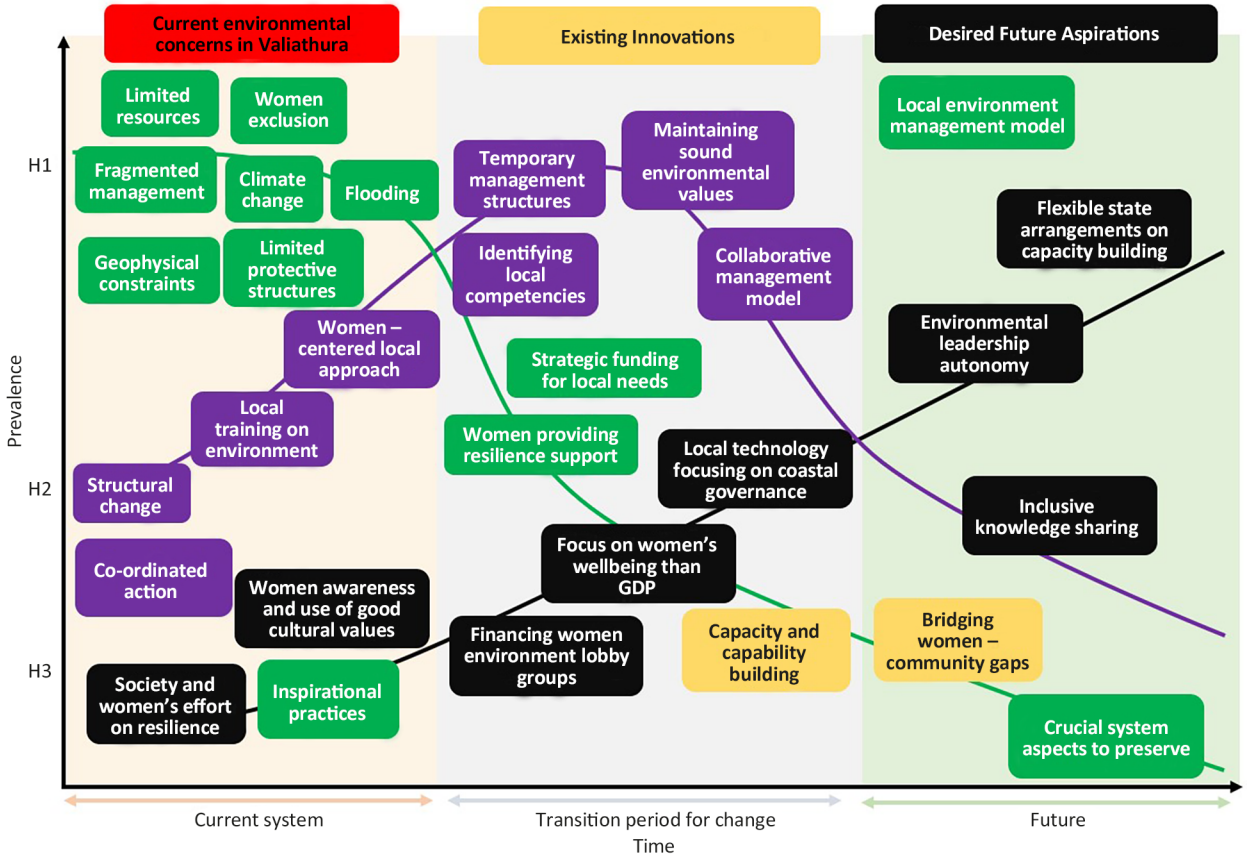

Fig. 6. Novel 3H Framework for reducing environmental shocks (source: elaborated by the Authors)

women, and the use of local coastal management structures such as artificial sand walls, bamboo reefs, and mangrove fences could be a pivotal and sustainable practice that leads to *H3* (Curry and Hodgson, 2008; GoK, 2018).

Relevance of the model in the context of sustainable development and environmentally vulnerable zones in other regions/zones

A limited number of studies have documented that the ocean and coastal zones are the future of global sustainable development and sustainability (IOC-UNESCO, 2020). This perspective is hinged on the acknowledgment of the value of ocean resources, goods, and services that they offer to both coastal communities and the global economy (IRP, 2021). This is further supported by the 2021 World Ocean Assessment Report, which observed that ocean resources are key to a sustainable Blue Economy and the attainment of the future we want as envisioned in the United Nations Decade of Ocean Science for Sustainable Development (2021–2030). To reap the benefits of the ocean resources and the innumerable services, research has recommended that it will require the creation of Ocean Best Practices Systems (OBPS), including on the use of ocean resources, that enable interoperability and functioning of both human and marine ecological systems (Fazey et al., 2016; Pearlman et al., 2021). Unfortunately, in many jurisdictions – including coastal and oceanscapes with a paucity of marine resources such as fish – these system interactions have been jeopardized by a number of poor ocean practices, and further threatened by the increasing environmental shocks and disasters, and particularly by climate change (IOC-UNESCO, 2020; Pearlman et al., 2021). For instance, since the 1970s, the explosion of pop-

ulation and increased sedentary settlement in coastal zones has ballooned marine biodiversity losses and increased water stress partly due to the over-extraction of resources such as fish and sand (OECD, 2016; Matovu et al., 2023). If this trend continues unabated, the 2021 International Resource Panel report warns that it would sprawl irreversible consequences on the functioning of ecosystems by 2060.

One key conundrum is that these consequences are evident and prominent in vulnerable coastal zones, including in the Global South, where local communities are not only vulnerable but also have relatively less capacity and knowledge on how to navigate through these increasing stresses and shocks (Shimabukuro et al., 2022). These vulnerable zones include coastal communities in Small Island Developing States (Matovu and Raimy, 2022). It is further noted that the lack of an understanding of how human-environmental systems interact is affecting knowledge on how to utilize resources, which sustain livelihoods (WOA II, 2021). Our study contributes to bridging this gap by developing a novel framework based on the understanding of the Iceberg model and 3H Framework of system thinking. The relevance of our framework is well demonstrated and supported by research in parts of Africa and Asia that reveal negative externalities in environmentally sensitive areas, which demonstrated that the lack of local understanding of local system dynamics proliferated environmental concerns – for instance, those related to solid waste management in wetland zones (Bbira and Nabukonde, 2022), management of wetland and lacustrine water bodies that provide food and freshwater resources in places such as Mityana (Matovu et al., 2019) as well as in Okinawa Island where increased saltwater intrusion (due to climate change) is threatening the provision of fresh groundwater (Shimabukuro et al., 2022).

In our 3H Framework, we propose that navigating through these complex scenarios not only requires a baseline understanding of local systems (in terms of socioeconomic components, among other things) but also an emphasis on the use of transdisciplinary approaches that could aid in the co-creation of new ideas for transition and development of comprehensive systems for the future desired by a given community (*H3*) (Curry and Hodgson, 2008). This systematic process has been applied in Okinawa with the use of simple tools such as board games to educate local communities – including young children and elders. These environmental education tools were used to promote understanding and learning on integrated resource management of the water cycle on coral reef islands (Shimabukuro et al., 2022). A research amongst vulnerable fisherfolk around Lake Wamala in Uganda revealed that systemic barriers – for example, shared knowledge of the benefits of managing lacustrine wetlands for balancing ecological-livelihood needs – partly limited local-led management initiatives (Matovu et al., 2019). Our framework could bridge this gap as it proposed that for communities threatened by environmental threats such as climate change, freshwater reduction, and species decline, the examination of systemic barriers in the current system could be key in developing inspirational practices and initiatives for the change needed at local levels and beyond; and this could be scaled to national, regional and ultimately global levels (Waddock et al., 2015; Sharpe et al., 2016). Though we contend that our novel 3H pathway might be dotted with some comprehension challenges and limitations – also among local communities – especially since we based it on the complex analysis and visualization of two system thinking models, and the data used to develop the framework was based on a non-systematic literature review, it offers a significant starting point for co-creation of system-transformative changes. This is because, for each Horizon, simplified themes and ideas that determine a given level of transitional change or uncertainty over time are indicated. This means that for regions, which either experience, or that are highly vulnerable to, environmental shocks and stressors, the key to building resilience could be determined by understanding the level of prevalence of a shock, spatial and temporal dimensions, and the local structures/community capabilities needed for the transformative change (WOA II, 2021). This could help in co-designing future interventions for transformative change (OECD, 2016; IOC-UNESCO, 2020; IRP, 2021).

CONCLUSION

The 3Hs Framework that we have developed offers a simple qualitative overview of how local systems, actors, and structures could manage transitions by identifying the existing shocks and patterns of environ-

mental disasters, which increase the vulnerability of livelihoods. This forms the basis of understanding how to design practices to mitigate environmental shocks in highly vulnerable areas (Curry and Hodgson, 2008) – for instance, in Valiathura – and identify sustainable practices that can lead to a desired future for inclusive and practical involvement of those most vulnerable in a community in increasing resilience to environmental shocks (GoK, 2018). This would facilitate increased participation by women and local community in general in designing strategies that are a direct response within the incremental range of the first horizon system (Ison et al., 2014). This could further help free local governance systems and institutions to explore a wide range of transformational possibilities by drawing on both what they see out in the world and amongst local community initiatives as responses to the changing context of environmental shocks, and their own visions and aspirations (Folke, 2006; Folke et al., 2010). This increases the voice of local people, women included, in building dialogue between local governance institutions that have responsibility for the present pattern – and for the the local communities – in seeking a path of transformation to the future (Sathiadas et al. 2004; IRP, 2021). Through experiencing such dialogue, vulnerable coastal zones and communities can freely express or co-create ideas and interventions based on their experience, thus creating a renewed sense of hope brought about by a greater understanding of how actions in the present can contribute to emerging futures and innovations that are locally led – but also highly resilient and adaptive to environmental shocks.

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STOSOWANIE PODEJŚCIA SYSTEMOWEGO W CELU ZWIĘKSZENIA ODPORNOŚCI SPOŁECZNOŚCI PRZYBRZEŻNYCH NA KRYZYSY EKOLOGICZNE: STUDIUM PRZYPADKU OBSZARU PRZYBRZEŻNEGO VALIATHURA W INDIACH

ABSTRAKT

Cel badań

Na całym świecie narastające kryzysy ekologiczne w strefach przybrzeżnych regionów tropikalnych paraliżują interakcje między człowiekiem a systemami środowiska, uniemożliwiając działania, które promowałyby zrównoważony rozwój. Jednowymiarowy charakter kryzysów ekologicznych utrudnia adaptację ludności zamieszkującej obszary przybrzeżne, której życie i utrzymanie w dużym stopniu są uzależnione od zasobów morskich i środowiskowych. Obecna polityka dotycząca odporności na kryzysy ekologiczne ma głównie charakter liniowy, negując oddolne zasoby społeczności przybrzeżnych, które mogłyby przyczynić się do rozwijania synergii w zakresie adaptacji i do łagodzenia skutków wspomnianych kryzysów.

Materiał i metody

Wykorzystaliśmy model myślenia systemowego Iceberg („model góry lodowej"), aby zidentyfikować i opisać dynamikę systemu lokalnego w odniesieniu do podatności na kryzysy ekologiczne oraz model ramowy 3Horizon („trzech horyzontów"), aby zidentyfikować – w ujęciu jakościowym – preferowane scenariusze, dobrze rokujące na przyszłość. Dotyczą one między innymi sposobów wypracowywania odporności kobiet na kryzysy ekologiczne (umiejętności czy strategii radzenia sobie z takimi kryzysami) na obszarach przybrzeżnych, traktując Valiathurę w Kerali jako studium przypadku.

Wyniki i wnioski
Opracowaliśmy nowatorski model systemowy Three Horizon (3H), uwzględniający aktualne wskaźniki systemowe w regionie Valiathura, które można wykorzystać do zrozumienia kryzysów ekologicznych i sposobów radzenia sobie z nimi. Na podstawie opracowanych ram zidentyfikowaliśmy możliwe ścieżki – algorytmy działań, które mogą zostać wykorzystane przez ludność i administrację regionów przybrzeżnych w Valiathura i w innych jurysdykcjach w celu promowania zrównoważonych zmian – w kolejnych etapach, czyli „horyzontach" 1, 2 i 3. Jednym z istotnych działań byłoby edukowanie i zwiększanie wiedzy lokalnych kobiet na temat kryzysów ekologicznych i wykorzystywanie tradycyjnych metod i strategii w celu zwiększenia adaptacji i odporności na kryzysy ekologiczne w obszarach nadmorskich i przybrzeżnych. Aby można było opracować plan zrównoważonych działań w strefach przybrzeżnych dotkniętych kryzysami ekologicznymi, konieczne jest skupienie się na zrozumieniu dynamiki systemu – co ma kluczowe znaczenie dla zrozumienia interakcji systemowych i informacji zwrotnych, które mogą pomóc w działaniach promujących zmiany transformacyjne, np. związane z adaptacją i łagodzeniem skutków kryzysu ekologicznego.

Słowa kluczowe: myślenie systemowe, kryzys ekologiczny, odporność społeczności przybrzeżnych, nowatorskie ramy Trzech Horyzontów, Valiathura – Indie