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ORIGINAL ARTICLE

Harnessing multiple domains of adaptive capacity: insights from the COVID-19 pandemic

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Abstract

The global community has been faced with multiple shocks in recent years, including the COVID-19 pandemic and increasing climate-driven environmental changes. Whether and how people can respond to such shocks depends on multiple factors, collectively referred to as adaptive capacity. Here, we explore how people in five coastal Kenyan communities drew on multiple domains of adaptive capacity to respond to the food security, livelihood, and well-being impacts of COVID-19. We undertook qualitative interviews across three time periods through the first year of the pandemic. We analysed them using a combined deductive and inductive coding strategy based on a recently developed theoretical framework outlining six "domains" of adaptive capacity: assets, flexibility, social organisation, socio-cognitive constructs, learning, and agency. We found that people responded to the impacts of COVID-19 across a continuum from temporary coping strategies to more substantial adaptations and transformations. We not only found that people drew from all six domains of adaptive capacity but identified multiple interdependencies between these domains which shaped how they influenced responses. For example, people's social networks (part of the organisation domain) played an important role in facilitating their access to assets and learning opportunities, and influenced their socio-cognitive constructs, which in turn influenced the adaptive actions they could take. Our findings suggest that policies and interventions to build adaptive capacity and resilience would benefit from a multi-dimensional approach that accounts for interactions between domains of adaptive capacity.

Keywords Adaptive capacity · Adaptation · Transformation · Shocks · Coping strategies · Small-scale fisheries · Kenya

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Introduction

In the last three years, the global community has experienced multiple, unprecedented social and economic crises arising from climate-driven natural disasters, international conflicts, and of course, the COVID-19 pandemic. These events have led to food system breakdowns, rising inequality, and an additional ~ 150 million people entering extreme poverty (Laborde et al. 2021; Swinnen and Vos 2021; Mottaleb et al. 2022; Vos et al. 2022). In the face of these kinds of shocks, people are forced to adapt in order to maintain their livelihoods, food security, and well-being (Adger et al. 2003). However, different people can respond to similar impacts in diverse ways (Béné and Doyen 2018).

Whether, and how, people respond to shocks is shaped by their adaptive capacity, that is, their ability to minimise, cope with, take advantage of, and recover from the changes they experience (Adger and Vincent 2005; Gallopín 2006). Multiple interconnected factors are theorised to facilitate different aspects of adaptation (and thereby comprise different aspects of adaptive capacity Yohe and Tol 2002; Mortreux and Barnett 2017; Cinner et al. 2018)). However, most adaptive capacity literature remains theoretical; takes a limited definition of adaptive capacity; measures it without directly linking it to responses; is extremely general and does not adequately engage with local contexts; or is based on analyses of hypothetical scenarios and pro-active actions (Smit and Wandel 2006; Mortreux and Barnett 2017; Cinner et al. 2018; Berrang-Ford et al. 2021; Bartelet et al. 2023). Little research to date has empirically examined how different aspects of adaptive capacity are associated with different types of responses within specific contexts (Barnes et al. 2020; Salgueiro Otero et al. 2022; Salgueiro-Otero et al. 2022; Bartelet et al. 2023; Brullo et al. 2024; Chapagain et al. 2025).[1] Additionally, while there has been research on interactions between some of the factors associated with adaptive capacity (for example there is extensive evidence linking social networks and access to resources both within and beyond the adaptive capacity literature Lin 1999; Adger 2003; Dapilah et al. 2020)), there has been little systematic consideration of these interactions within the empirical research on the multiple factors associated with different adaptations (Cinner et al. 2018). A better understanding of the multiple dimensions and functional mechanisms of adaptive capacity is critical for pro-actively preparing to deal with future shocks arising from the climate crisis and other social and ecological changes.

The spectrum of adaptive responses

Responses to shocks can vary in scale from temporary strategies to minimise impacts, to complete reorganisation of social-ecological system structures (Béné and Doyen 2018). There is a wide range of terms used to categorise different types and levels of adaptive behaviours within and across disciplines and scales, which can easily lead to confusion unless the intended meaning of key terms is established (Gallopín 2006; Smit and Wandel 2006; Jakku and Lynam 2010; Béné and Doyen 2018; Siders 2019; Zanotti et al. 2020) (e.g. see Berman et al. (2012) for a summary of various definitions of coping, coping capacity, adaptation, and adaptive capacity). Here, we use *responses* as a general term to refer to any kind of changes made in response to an experienced or anticipated shock. We define *coping strategies* as short-term responses aimed at buffering, absorbing, or "riding out" the immediate effects of shocks, with the intention of returning to the previous status-quo (Corbett 1988; Lemos et al. 2013) (Fig. 1). *Incremental adaptations* refer to adjustments to existing practices and system structures in response to change which still maintain the general system functions and characteristics (Nelson et al. 2007; Béné et al. 2014) (Fig. 1). *Transformations* are more fundamental changes, generally implemented when shocks make existing practices untenable, including novel, large-scale adaptations, relocations, or alterations to dominant system structures (Walker et al. 2004; Kates et al. 2012; Béné et al. 2014; Filho et al. 2022) (Fig. 1). It is important to note that the degree to which a given adaptation is incremental vs transformative is best represented by a spectrum, rather than discrete categories, and can vary between individuals and contexts (Manyena 2006; Kates et al. 2012; Lemos et al. 2013; Béné et al. 2014; Barnes et al. 2017). However, these kinds of discrete categories do draw out some key distinctions and can be helpful for unpacking complex concepts (Béné et al. 2018).

Responses at all three levels can lead to neutral, positive, or negative outcomes (or a combination thereof) for different actors and the broader social-ecological system they are embedded in (Turner et al. 2010; Adger et al. 2011). Responses that result in primarily negative outcomes are termed *maladaptive* (Scheraga and Grambsch 1998; Juhola et al. 2016; Magnan et al. 2016; Schipper 2020). Coping strategies frequently become maladaptive if maintained long term, particularly in the context of food and income

[1] Note that in some literature rather than referring to adaptive capacity as a set of attributes which can facilitate coping strategies, incremental adaptations, and transformations, it is instead the convention to differentiate between coping or absorbative capacity, adaptive capacity, and transformative capacity (Turner et al. 2003, Berman et al. 2012, Béné et al. 2014). However, as our findings in this paper demonstrate, many of the factors which make up an individual's adaptive capacity are required to implement responses across the spectrum from coping to transforming, and as such we use the term adaptive capacity to refer to the capacity to respond at any level and then differentiate between different types of responses.

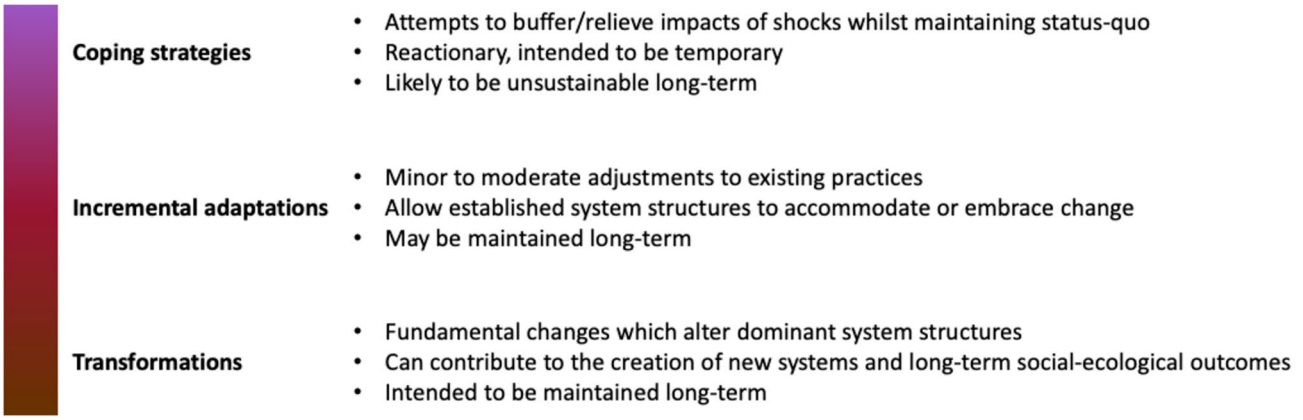

Fig. 1 Spectrum of levels of adaptive responses from coping strategies to transformations

insecurity, as they are often unsustainable and are often associated with eroding long-term adaptive capacity (Corbett 1988; Lemos et al. 2013). On the other hand, shocks have the potential to be tipping points which prompt paradigm-shifting transformational responses and can lead to more sustainable and beneficial futures (Herrfahrdt-Pähle et al. 2020; Markard and Rosenbloom 2020; Brulé 2023; Csutora and Zsóka 2023). For example, in small-scale fisheries, COVID-19 saw much-needed general worker health and safety protocols instigated and new local food supply chains and distribution methods established (Bassett et al. 2021). The factors which lead to coping strategies vs. incremental adaptations vs. transformations are likely to be different, stemming from different levels and forms of adaptive capacity (Wilson et al. 2013; Béné and Doyen 2018).

Adaptive capacity

Recently, Cinner and Barnes (2019) integrated diverse research across the social sciences into a cohesive framework for understanding adaptive capacity. The framework outlines six interconnected domains, which can facilitate or act as barriers to responses: assets, flexibility, organisation, agency, learning, and socio-cognitive constructs. *Assets* consist of the finances, technology, and services which people have access to (Cinner et al. 2009; McClanahan and Cinner 2011). *Flexibility* refers to the ability to choose from a diverse range of strategies (Cinner et al. 2018). *Social organisation* refers to the relationships between individuals, communities, institutions, and governance structures at multiple scales which enable or inhibit responses (Adger 2003; Cinner et al. 2018). *Learning* is about people's capacity to access information, process it to identify change, make causal attributions, evaluate potential responses, and manage uncertainty (Fazey et al. 2007; Cinner and Barnes 2019). *Socio-cognitive constructs* are the mental frameworks such as risk attitudes and cognitive biases which shape perceptions of shocks, the necessity and possible benefits of potential responses, and decisions about whether and how people should act (Mortreux and Barnett 2017). In the context of adaptation, *Agency* is the power to make free choices about whether or not to make changes, and if so, how (Brown and Westaway 2011; Cinner et al. 2018).

Importantly, high levels of adaptive capacity in any of the six domains do not automatically lead to responses and may lead to both positive and negative outcomes. For example, increased access to more efficient fishing gears (assets) may result in temporary benefits in the form of higher catches, but in the long term cause an ecological collapse (Cinner and Barnes 2019). Additionally, these domains are interlinked (Smit and Wandel 2006); for example, social networks can facilitate access to assets and learning opportunities (Barnes et al. 2017).

Adaptation to COVID-19

The COVID-19 pandemic provides an opportunity to examine how people respond to multi-dimensional shocks, what factors influence their ability to make different kinds of responses, and how those factors interact with each other. Both the outbreak of the disease and the subsequent policies across the world to slow its spread led to disruptions to food production and value chains, increased food prices, unemployment, infrastructure breakdowns, a reduction in social support systems, and overall economic decline (Béné 2020; Erokhin and Gao 2020; Harris et al. 2020; Schmidhuber 2020; Kundu et al. 2021; Love et al. 2021; Nyiawung et al. 2022, 2024; Sutcliffe et al. 2023; Mangubhai et al. 2024). These kinds of disruptions are likely to reoccur with increasingly frequent and severe natural disasters and resource conflicts under climate change. As such, some of the lessons from experiences of and responses to COVID-19 may be applicable to future shocks (Manzanedo and Manning 2020; Cooper and Nagel 2021; Negev et al. 2021;

Pelling et al. 2021). Much of the early research on the social and economic effects of the COVID-19 pandemic in fishing communities focused on documenting impacts and identifying individual adaptations (Stephens et al. 2020; Belton et al. 2021; Love et al. 2021; Tripathi et al. 2021; Alam et al. 2022; Schreiber et al. 2022; Khan et al. 2023; Marsden et al. 2023; Nyiawung et al. 2024). There is still a need to understand the different types of adaptive responses people made or did not make, and more importantly, how and why (Love et al. 2024). This information can help inform policies and programs that will build adaptive capacity and help communities to navigate future shocks more effectively.

Here, we empirically examine the role of the multiple domains of adaptive capacity in shaping various responses to the COVID-19 pandemic, using five small-scale fishing communities on the south coast of Kenya as a case study. We first explore the types of responses community members made across the first year of the pandemic. We then examine how each of the six domains of adaptive capacity facilitated or acted as a barrier to responses or where a lack of adaptive capacity forced people into making changes they did not want. We explore some of the interdependencies between the domains and then conclude with some reflections on the applicability of this research to responses to other shocks.

Methods

We conducted a total of 99 semi-structured interviews with 39 interviewees from five small-scale fisheries-dependent communities in Kilifi and Kwale counties on the south coast of Kenya during the first year of the pandemic. In June 2020, the Kenyan government put in place several measures to stem the spread of COVID-19, including school closures, curfews, and limits on social gatherings, transportation, movement, and permitted business activities. The southern coastal counties of Kilifi, Mombasa, and Kwale had some of the highest case rates in the country, and as such were subject to more stringent restrictions than elsewhere in Kenya, including the implementation of county border closures (Ministry of Health 2020). These restrictions cut the study communities off from the closest major markets in Mombasa where a large proportion of their fish catch is sold, resulting in reduced prices and sales (Lau et al. 2021). Coastal areas around Mombasa were greatly affected by a drop in tourism, which lead to a loss of industry jobs and reduced demand for fish from hotels (Lau et al. 2021). Curfew hours, social distancing requirements, and movement restrictions all disrupted fishing and marketing activities. Overall economic decline in the region reduced demand and lowered prices for fish. These factors lead to an overall decline in income, food security, and well-being for fishers and their communities (Lau et al. 2021; Sutcliffe et al. 2023).

We interviewed three women and three men in each community (Table S3). We identified potential interviewees from a list of previous participants in research we had conducted in the communities who had provided us with contact information and indicated their willingness to participate in future research. (This previous research was the primary reason these sites were selected for this study, as we had baseline data and contextual familiarity as well as existing relationships and contact information for community members which allowed us to conduct the research entirely remotely during the pandemic. Further descriptions of the communities and their original selection criteria can be found in Barnes et al. (2019) and Lau et al. (2021)). The list of previous research participants was sorted by age group, and then we randomly selected people from each age group and invited them to participate. The men we interviewed were primarily fishers, and women were either fishers/gleaners or local fish traders known as Mama Karangas. Each person was interviewed three times over the first year of the pandemic, in July–October 2020, November–December 2020, and January–March 2021. We also interviewed a local leader in each community (e.g. a village chairperson or Beach Management Unit executive) in the first and third round of interviews. Finally, we conducted one-off interviews with four fish traders to better understand the effects of COVID-19 policies further down the value chain which were rebounding back on fishers in the study communities.

Interviews took between 30 min and 1 h. The interviews were conducted by phone in Swahili by trained local interpreters who have been working with our partners in these communities since 2015. Interviews were then transcribed and translated by the interviewers then cross-checked by co-authors. Interviewers first prompted participants to describe their experiences since the onset of the COVID-19 pandemic. They were asked to identify what COVID-19 containment policies were in place in their community and how these policies were impacting livelihoods, food security, and overall well-being (see Appendices 3–5 for interview templates). Interviewers prompted participants to explain how and why the changes they described occurred with the aim of eliciting information about the relationships between different impacts. They then asked participants to describe changes they had made in response to those impacts to ensure they were able to meet their needs. Community leaders were asked similar questions but acted as key informants for experiences of the whole community. Fish traders were asked about changes to how they bought, transported, and sold fish and how those changes affected them.

We analysed the interviews in NVivo using a combination of deductive and inductive coding, following standard qualitative research principles (Newing et al. 2011; Linneberg and Korsgaard 2019). We first open-coded the interviews to identify specific coping strategies,

incremental adaptations, and transformations participants either made or wanted to make (but were unable to do so) in response to the impacts of COVID-19. Similar responses were grouped to facilitate interpretation (see Table S1 for full list of codes).

We then deductively coded each adaptation to one or more of the six domains of adaptive capacity which either facilitated the adaptation, acted as a barrier to the adaptation, or where a lack of capacity forced people into making an undesirable (mal)adaptation. While in some cases participants explicitly identified things that facilitated, prevented, or forced adaptations, in other cases we had to infer the relevant domain(s) from context. For example, when people talked about using ice to preserve fish overnight because they could not sell it when they returned from sea in the evenings due to the curfew, we inferred that they were drawing on assets (i.e. buying ice or owning a freezer, which is rare). This method of inference from qualitative interviews is particularly appropriate for researching complex behaviour and motivations in highly context-specific situations where pre-defined survey tools may not be sufficiently nuanced, and/or where there are constraints on data collection which make large-scale quantitative approaches impractical (Denzin 2005; Cox 2019; Bercht 2021). Coders consulted extensively with co-authors and in-country partners to review the coding, resolve uncertainties, and clarify interpretations.

The majority of the results presented are purely qualitative, though in some instances we have reported basic quantitative data about the frequency of different responses. We could not statistically test for differences in responses between communities due to the small sample size, which would make any such tests underpowered. However, general exploratory analysis indicated a high degree of heterogeneity in the responses of different individuals within communities, with no clear evidence of community clustering (Fig. S1). As such, we have combined results across all the communities where we have presented quantified results.

Results

Responses to the shock

Based on our interviews, we identified 206 instances where individual participants (not including leaders and traders) made a change in response to the impacts of COVID-19 in the first year of the pandemic. These included 64 unique responses which we subsequently grouped into 17 broad categories, nine of which we classified as types of coping strategies, six as types of incremental adaptations and two as types of transformations (Table 1, Table S1).

Coping strategies

All participants reported implementing coping strategies to relieve the immediate impacts, particularly income loss, and many maintained these strategies throughout the study period. Dietary changes like reducing dietary diversity and overall food intake (Table S1) were the most common coping strategy. 93% percent of households reported making

Table 1 Examples of coping strategies, incremental adaptations, and transformations undertaken in coastal Kenya as a result of COVID-19 and its containment policies

	Example 1	Example 2
Coping strategies	Consuming less food: "We were forced to change because when you get fish and don't sell them, if you used to cook 2 kg of ugali you'll be forced to reduce and only cook 1/2 kg for children to eat and drink water and call it a day. That's how it was, when you became lucky to get breakfast, you skip lunch and eat supper." (F, 46, community B)	Selling productive assets at low prices: "When corona started, we had goats and chickens and we sold them one by one to get money for food…When corona started the only source of income was the animals and there was no money, so you are forced to sell very cheap compared to what you really expect." (M, 21, community A)
Incremental adaptations	Changing proportional effort invested in different livelihood activities: "We used to juggle between casual construction works and fishing but now I spend most time fishing." (M, 24, community B)	Selling fish to consumers directly instead of through traders: "When I came with fish there were no fish traders to sell the fish to, so I was forced to walk from house to house to sell them" (M, 48, community B)
Transformations	Migrating: "In towns the population has decreased, and many people have gone back to their rural homes. They moved from towns where they were used to living and where they were supposed to get jobs, but they are not there now." (Leader, community B)	New livelihoods: "I am doing farming. I got a plot and did a tomato nursery with 900 seedlings. So, I sell one bucket at KES500 (~ 4USD) and at least get some profit. I saw that it is better to have a tomato nursery." (M, 48, community B)

at least one dietary change in the first round of interviews in July–October 2020, with 43% maintaining at least some dietary changes through to early 2021.

Some participants were able to seek out support from friends and family or from institutions, particularly in the initial months. Several participants took out cash loans or store credit to cover immediate needs. By October 2020, several participants had used savings or sold or consumed household assets (e.g. livestock), often at reduced prices, to make up for lost income.

Some participants reported engaging in illegal activities, particularly breaking curfews, and other COVID-19 restrictions, because they felt that the consequences for not complying with restrictions were less severe than the threat of food insecurity. Participants also implemented a range of minor adjustments to their daily lives to limit their exposure to COVID-19, which increased as people became more aware of both risks and containment strategies.

Incremental adaptations

Participants made a range of incremental adaptations, particularly during the first 6 months of the pandemic. Some of these were maintained through the study period, and some new incremental adaptations were adopted in later rounds, but most people returned to previous practices towards the end of 2020. Incremental adaptations included selling fish in communities within their counties instead of to traders for export to Mombasa; fishing during the day instead of at night to comply with curfews; and introducing post-harvest processing activities. Many participants shifted the proportional effort they were putting into different livelihood activities they were already engaged in. For example, in some of the communities, prior to COVID-19, a much higher proportion of people had paid work in factories, tourism, or construction etc., and only fished occasionally to supplement their income or for direct consumption. When many of these industries all but shut down, those people turned to fishing as their primary livelihood. In contrast, in the communities which were more heavily reliant on fisheries for income, particularly fishing for high-value fish to sell in Mombasa markets and to tourist hotels, people who would normally only occasionally take on casual construction jobs or informal economic activities like selling snack foods or doing laundry increasingly relied on that work to supplement lost income from fisheries when fish value chains broke down. Similarly, some participants increased their investment in farming at various scales.

Transformations

Relatively few participants made major transformations, as defined here. Some participants migrated out of their communities in the hope of being able to find work elsewhere. Some participants took up completely new livelihood activities, for example switching from fishing to farming. However, these switches likely had mixed results. One leader stated that these were not always beneficial changes, as people were switching to low-income livelihoods, and often lacked the knowledge and experience to make them successful. In addition, the pandemic coincided with a severe drought, which severely undermined the potential benefits of investing in agriculture as a transformative strategy.

Role of the six domains of adaptive capacity

We identified three mechanisms through which adaptive capacity influenced responses to the impacts of COVID-19. (1) High capacity in a particular domain enabled people to take a specific action; (2) low capacity forced people to take a specific undesirable action; and (3) low capacity prevented people from taking a desired action. We classed adopting a particular strategy as using adaptive capacity to facilitate an action when people were consciously choosing to take a particular action, even knowing it may have negative outcomes. In turn, when people were forced to take that action due to a lack of other viable alternatives, we identified it as a lack of capacity forcing an undesirable action. Figure 2 shows the relative number of interviews which made the link between each domain of adaptive capacity, influencing mechanism and level of response (i.e. the proportion of the community affected by a lack of or abundance of a particular domain, not the scale of influence on individuals). A lack of adaptive capacity particularly prevented transformative responses. Each of the six domains were important for facilitating or preventing various responses, though to varying extents, and a lack of assets, agency, social organisation, and flexibility all forced people into taking undesirable actions (Fig. 2, Table S1).

Flexibility

Flexibility was critical to facilitating responses at all levels, but particularly incremental adaptations. People who already had multiple options available to them and/or who were already engaged in a diverse range of activities were able to shift strategies and transition effort more easily to less-effected food and income sources. For example, as restrictions and behaviour patterns fluctuated, some Mama Karangas (female fish traders) exercised flexibility to deal with extreme shifts in fish supply, demand, and pricing. To maintain a business presence and attempt to maximise their profits as circumstances changed throughout the course of the pandemic, they switched between buying fish at landing sites and fish shops; selling fish from stalls at the side of the road, from their homes or going door to door; and changed

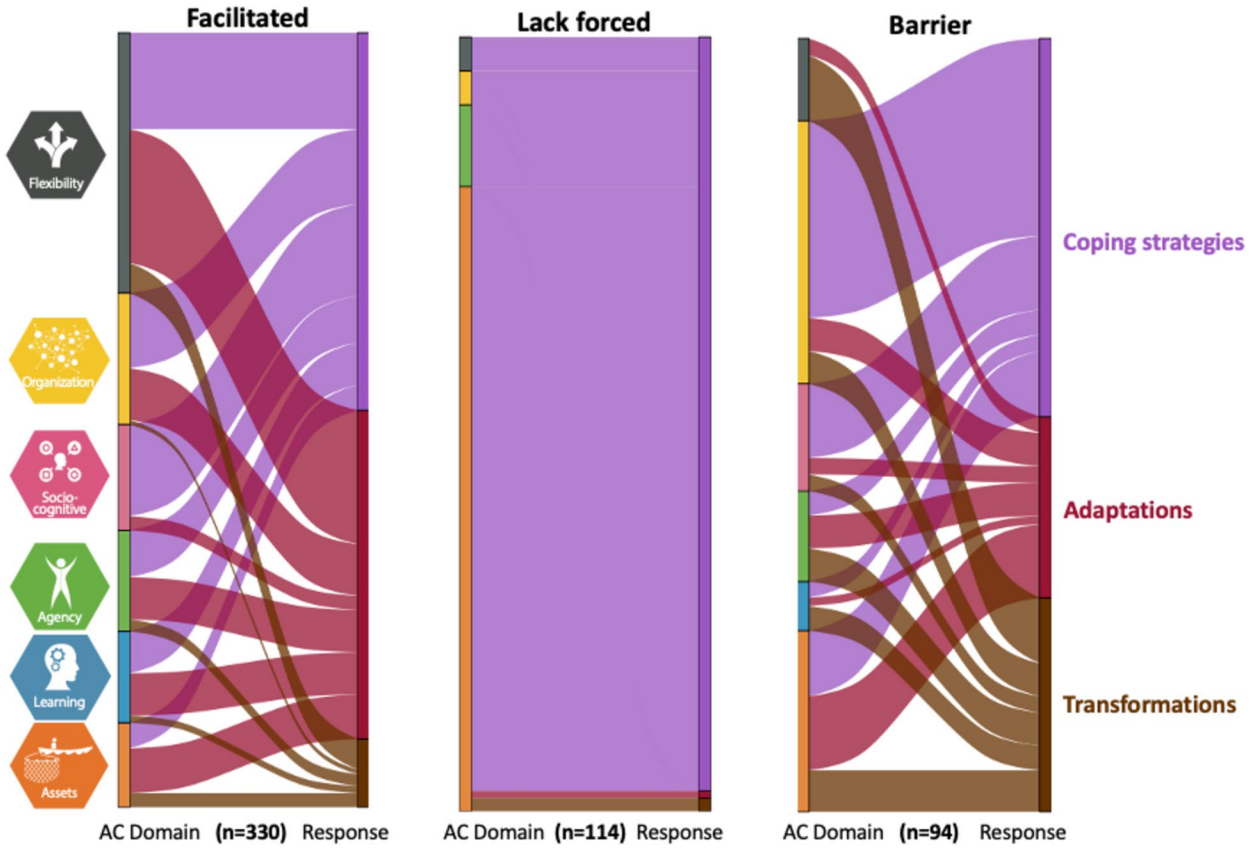

Fig. 2 Relationships between responses and adaptive capacity domains. Alluvial plots showing **A** which domains of adaptive capacity facilitated specific responses, **B** where a lack of a specific domain forced people into taking an undesirable action, and **C** where a lack of a specific domain was a barrier to a planned response, each aggregated across all three time periods. The thickness of segments on the axis and the bands indicates the relative number of interviews which made a link between a particular domain of adaptive capacity leading to or preventing a coping strategy, incremental adaptation or transformation. The colours on the left axis correspond to the Adaptive Capacity Framework in Cinner and Barnes (2019). The colours of the bands and right axis indicate the level of response (Fig. 1). Icons are adapted from Cinner and Barnes (2019)

the species of fish they bought and sold depending on who was buying and at what prices. In contrast, other women and men either could not or would not alter, diversify, or switch livelihood strategies. They were unable to identify potential adaptations to existing livelihood activities and said that there were no alternative livelihoods available.

Social organisation

Social organisation was key for obtaining loans and social support, getting access to cold storage when fish could not be sold right away, and finding alternative markets when normal value chains broke down (Fig. 2, Table S2D). Some fishers and fish traders decided to share resources and distribute catch amongst themselves to minimise overheads and make up for reduced efficiency, particularly within groups that would normally work together every day but no longer could due to social distancing requirements. People without strong, established ties to shopkeepers were less likely to be able to get food on credit, and people with less friends and family struggled to find help. As one person put it "You will find that in the community if you don't have food you may ask from your friends and neighbours and they will give you, but if you are not used to people you may fail to get help." (Leader, community B). Arguably even more crippling was either a lack of ties to leaders and others with power and influence over resources, or when people in those positions were ineffective or corrupt (Table S2F)

Socio-cognitive constructs

Risk perceptions and social norms influenced whether participants felt the need to adapt and change their livelihoods, implement COVID-19 mitigation strategies, and comply with restrictions (Fig. 2, Table S2G). In some cases, these perceived risks led to people pro-actively implementing mitigation strategies while still trying to maintain income and

lifestyle. Other participants' perceptions of potential risks prevented action. They were concerned about the risks of contracting COVID-19, or about police shutting down small businesses, likely with extreme force, and felt it was safest to stay at home rather than attempting to find alternative ways to maintain their business or start new ones. Others felt there was no or minimal risk, and accordingly did not try to adapt to mitigate it. Others said that they were concerned about both the risk of contracting COVID-19 and of facing police enforcement but felt that the risk of food insecurity was more pressing and so continued fishing and other livelihood activities as normal. Social norms around self-sufficiency shaped whether people were willing to give or receive support to or from other community members (Table S2H).

Agency

Self-efficacy and perceived power were a key factor in whether people even tried to change their behaviours and mitigate the impacts of COVID-19. Some people actively evaluated their options and made strategic plans about how to maximise their income given the constraints they were under and then best budget and utilise the food and income they did get (Fig. 2, Table S2I). In contrast, multiple people said that if they could not buy and sell fish as normal, there was nothing else that they could do, even as others in similar situations around them were adapting. They continued fishing or fish trading, even when they were not making a profit, or even actively losing money and not getting paid for their fish (Table S2J).

Learning

People's ability to access and interpret information about the pandemic and associated rules and recommendations was a major driver of decisions about whether to pro-actively implement mitigation strategies and whether to comply with rules or continue in previous behaviours to maintain food and income security (Fig. 2, Table S2L). There was significant inconsistency in people's understanding of what was happening and what the restrictions were, particularly in the first round of interviews. Fishers and fish traders who were able to consistently identify market trends and adjust which species they targeted and sold, where and to whom, were better able to maintain their income. People's level of success in adjusting or taking up new livelihoods was influenced by their previous knowledge and experience, and whether they were able to quickly learn and adapt if they tried something new (Table S2M). Multiple people commented that it was difficult for them to get information about the pandemic, fisheries, and other important topics, and to discuss and collectively develop ideas about possible adaptations due to social distancing requirements.

Assets

Almost all participants reported being "forced" into making trade-offs between multiple negative outcomes due to a lack of assets (Fig. 2, Table S2O). For example, most participants were forced to choose between reducing the quality, quantity, or diversity of their diets, or often a combination thereof. In some cases, participants described situations where taking a particular maladaptive response created a negative feedback loop which continued to undermine their resilience and adaptive capacity. One woman described how, when demand for fish dropped, she was unable to sell all the fish she was buying, meaning she did not earn enough money to cover costs to purchase more fish to sell on subsequent days. Without income to buy other food and to avoid waste, she and her family were forced to consume her fish supplies directly. She started collecting gravel as an alternative livelihood activity because it did not require start-up capital, but it is a labour-intensive, low-profit activity. As a result, she struggled to earn enough to make ends meet, was not able to save enough to continue participating in the women's rotational savings groups, and was too tired to do other income-earning activities. She was unable to save up enough capital to re-enter the fish trade and was still collecting gravel in the final round of interviews after many other participants had returned to pre-pandemic livelihood activities and income levels.

Interactions between domains of adaptive capacity in influencing responses

We identified pairwise interactions between all the domains of adaptive capacity (Table 2). The clearest and most frequent examples of interactions between pairs of domains were between social organisation (ties to both peers and leaders) and the other domains. Organisation played a key role in facilitating access to aid and credit (assets) (Table 2D) and information and learning opportunities (Table 2L). Flexibility was often directly dependent on whether people had the necessary social ties, assets, learning ability, socio-cognitive constructs, and agency to switch strategies.

We also identified multiple more complex interactions between domains (Fig. 3). For example, interactions with experts coming into the community (facilitated by community leaders) to communicate with them about COVID-19 directly were particularly important for causing shifts in risk perceptions, thereby motivating and directing prevention behaviours in a way that hearing news and recommendations from external media sources did not (Fig. 3A). This example demonstrates the complex interactions between social organisation, learning, and socio-cognitive constructs. Relationships between peers within the community facilitated knowledge and resource exchanges which were critical for allowing people to start engaging in and succeeding in

Table 2 Examples of pairwise interactions between domains of adaptive capacity. Icons are adapted from Cinner and Barnes (2019)

	Flexibility	Agency	Learning	Organization	Socio-cognitive
Assets	**A)** Access to capital and supplies determined if strategies were possible (i.e., enabled flexibility) e.g., new livelihood opportunities which required inputs.	**B)** Access to phones determined whether people could participate in and influence community decision making when in-person meetings were cancelled and moved to online/calls and texts.	**C)** Access to technology largely determined access to information and learning opportunities when social distancing prevented personal interactions.	**D)** Social ties to leaders and other community members influenced access to credit, aid, and other assets.	**E)** Access to asset bases influenced people's perceptions of their ability to ride out the events of the pandemic vs. the need to adapt.
Socio-cognitive	**F)** Socio-cognitive constructs influenced which strategies people considered and whether they thought they were viable options, for example people who felt their identity was tied to fishing often said they felt they could not do anything else.	**G)** People's perceived ability to manage and control the events of the pandemic and their capacity to respond shaped decisions about whether and how to adapt.	**H)** Access to information and perceived reliability of information sources shaped risk perceptions and stimulated/prevented action.	**I)** Leaders' socio-cognitive constructs influenced whether they facilitated aid distribution and leveraged their own social connections to benefit the community.	
Organization	**J)** Connections to/ collaborations with peers created new opportunities through resource sharing.	**K)** The inability to meet in person limited people's ability to participate in collective decision making about community fisheries management	**L)** Social distancing rules limited social interaction and therefore opportunities to learn from each other and develop ideas.		
Learning	**M)** Access to information and the capacity for creative problem solving and sharing ideas shaped awareness of possible options and knowledge of how to implement them.	**N)** Increased understanding of the pandemic in later months allowed people to make informed, independent choices about how to balance mitigating COVID-19 risks and meeting other needs.			
Agency	**O)** Agency (particularly self-efficacy) shaped perceptions of what options were available and viable.				

new livelihood activities or strategies. In other words, social organisation facilitated learning and access to assets leading to increased flexibility (Fig. 3B). Additionally, agency and socio-cognitive constructs both shaped and were shaped by relationships between community members and leaders, and in turn influenced access to assets. In communities where leaders perceived that the pandemic posed minimal risk to their communities and believed that individuals had a responsibility to meet their own needs without external support, people within those communities did not receive timely aid and assistance (Fig. 3C). In comparison, in communities where leaders perceived the risk of COVID-19 and associated impacts on their community to be high, and felt they had the responsibility to support community members in meeting basic needs, they used their own influence to ensure resources were distributed to people most in need (Table 2D, Fig. 3C). On the other hand, expectation of aid and assistance from the government, combined with low self-efficacy, did mean that some people did not pro-actively adapt, and subsequently struggled when the promised aid was not delivered.

Long-term implications of responses to the shock

Finally, our results suggest that how people drew on their adaptive capacity during the pandemic may have exhausted avenues for adapting to change in the future, especially projects that would have supported general resilience in the longer term. Specifically, many participants expressed concern that their experiences during the pandemic had undermined their long-term resilience and adaptive capacity in the face of future shocks. Long-term projects and plans to develop new livelihoods and investments had been undermined. People suffered from malnutrition as well as physical and mental health impacts, some of which lingered even as restrictions eased, and incomes improved. There was particular concern that children were missing school and that families did not have money for school fees when they reopened because they were struggling just to bring in enough money for food. They worried that their children's futures had been harmed by increased crime, more frequent youth pregnancies, and a lack of education.

> I really wished to get a chance to see at least my child going far with education. It would have been good. But right now, my life is not so good. Children are not going to school and my business is not stable. I am not so much educated but through my personal jobs I used to get my daily bread and push on like that with life. Before corona, my priority was about education for my children. (F, 42, community D)

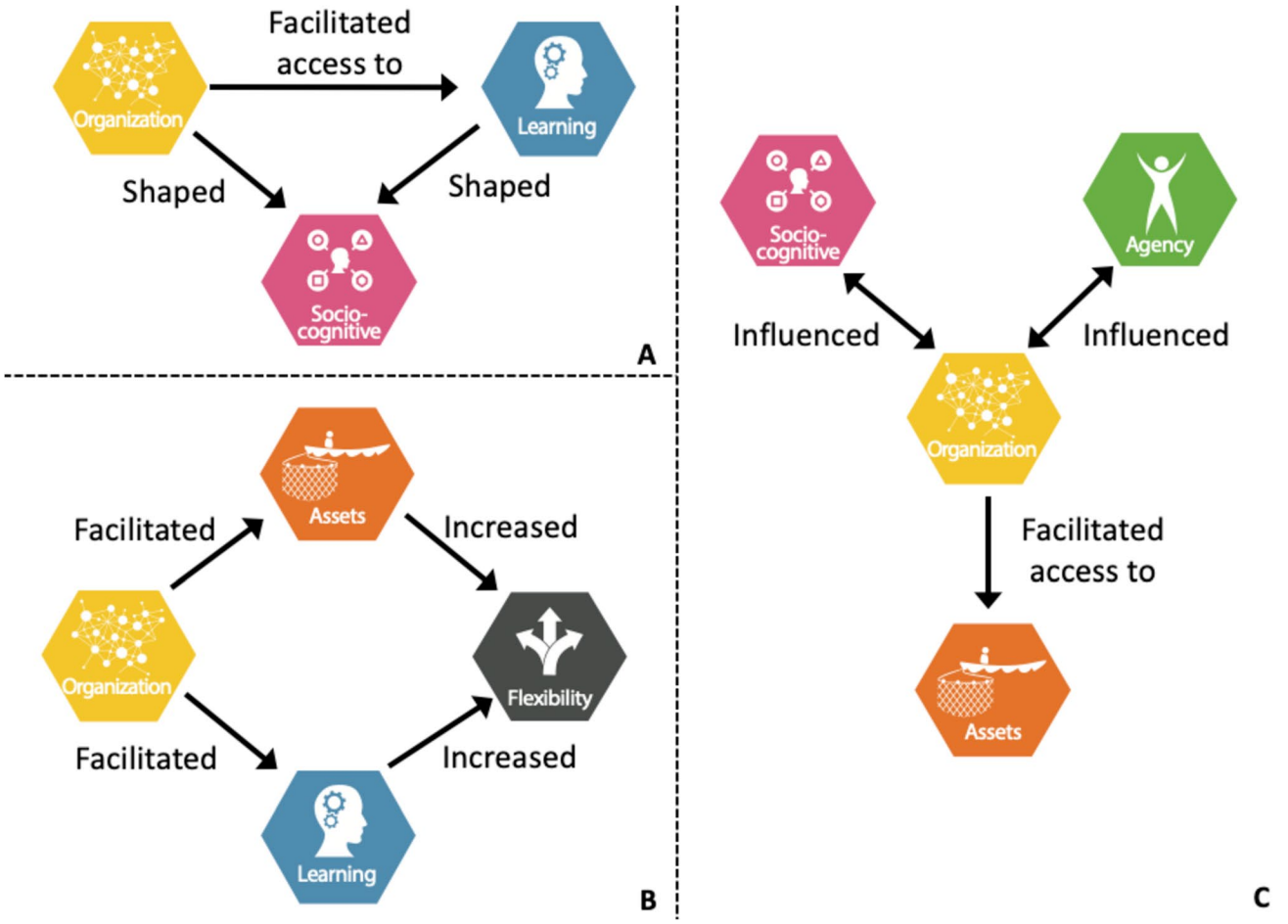

Fig. 3 Examples of complex interactions between domains of adaptive capacity. **A** Interactions with experts coming into the community, facilitated by community leaders (organisation) to communicate with people about COVID-19, were particularly important for informing people about implications of the pandemic for their community and preventative actions they could take (learning). This more effective learning mechanism caused shifts in risk perceptions (socio-cognitive constructs), thereby motivating and directing prevention behaviours in a way that hearing news and recommendations from external media sources did not. **B** Connections and collaborations with peers (organisation) meant that people were able to share knowledge and experience (learning) and resources like equipment (assets) which were essential to being able to participate in and succeed at new livelihood strategies and activities (flexibility). **C** Leaders' socio-cognitive constructs and sense of personal responsibility and agency determined whether or not they used their influence to support others in their community (organisation). In communities where leaders perceived that the pandemic posed minimal risk to their communities and believed that individuals had a responsibility to meet their own needs without external support, people within those communities did not receive timely aid and assistance. In comparison, in communities where leaders perceived the risk of COVID-19 and associated impacts on their community to be high, and felt they had the responsibility and capacity to support community members in meeting basic needs, they used their own influence to ensure resources were distributed to people most in need. Icons are adapted from Cinner and Barnes (2019)

While the second and third round of interviews suggest that most people were able to resume their previous livelihood activities, improve their diets, and resume their social lives once restrictions eased, there was ongoing concern about the long-term implications of these disruptions and associated maladaptations going forward due to lost momentum, reduced resource bases, and missed opportunities.

Discussion

Throughout the first year of the COVID-19 pandemic, participants engaged in a range of adaptative actions. Respondents described how all six domains of adaptive capacity helped them to respond to shocks, but also described how a lack of adaptive capacity forced them into taking undesirable actions and prevented planned responses. The six domains of adaptive capacity did not influence actions independently of each other, but interacted in complex ways to shape which responses people could engage in.

The spectrum of adaptive actions

Participants primarily engaged in coping strategies and incremental adaptations, with relatively few transformations. These strategies were broadly similar to the kinds of responses that other low-income rural households engaged in during the pandemic. A review of 84 papers evaluating the impacts of and responses to COVID-19 in fishing communities around the world by Nyiawung et al. (2024) identified engaging in alternative livelihood activities, changing fishing methods and fish marketing strategies, and drawing on relief, support, and aid were the main types of responses adopted by individuals. Belton et al. (2021) also identified that people involved in aquatic food value chains across Asia and Africa similarly responded to COVID-19 by drawing on social networks and reducing food consumption. Mangubhai et al. (2024)'s review paper additionally highlighted post-harvest value adding activities and drawing on savings and loans. This pattern is consistent with response patterns during previous social, economic, and environmental shocks which have disrupted food and income security. In a meta-analysis of household data from responses to diverse shocks in 35 countries from 2014 to 2020, d'Errico et al. (2023) found that while there were some differences in the kind of responses people took to different types of shocks, changing consumption patterns, livelihood diversification, selling assets, taking out credit, and drawing on social support networks are consistently the most common responses. The strong dependence on coping strategies relative to adaptive and transformative strategies is also consistent with what has been observed in other rural food-producing communities during COVID-19 (Meuwissen et al. 2021).

There are several likely explanations for why relatively few people undertook potentially transformative responses. Implementing transformations is harder and more confronting than implementing coping strategies and incremental adaptations. This is particularly the case in situations with a high degree of uncertainty and high perceived costs of transformative action (Kates et al. 2012). Transformations involving substantial livelihood changes or relocations are often perceived as actively undesirable in contexts where people have a strong sense of occupational and place attachment (Marshall et al. 2012), as is the case for many small-scale fishers (Urquhart and Acott 2013; Johnson 2018). With some exceptions, the interviews indicated that most participants did not take transformative actions because they felt that transformations were not necessary, rather than because they were prevented from making desired changes due to a lack of capacity. In general, the way people frame problems can place limits on the potential solution space they consider and whether they prioritise immediate needs or long-term resilience in their decision-making (Adger et al. 2011). This framing of the pandemic as a sudden but temporary hindrance to get through rather than a long-term shift to adapt to is a major point of divergence between perceptions of and potential responses to the pandemic and climate change, which is a protracted, escalating crisis (Pahl et al. 2014). As such, it limits the extent to which we can draw direct comparisons between people's responses to COVID-19 and their ability to make transformative changes in response to recuring and protracted climate impacts. This is an ongoing issue within resilience and adaptation research, which is dominated by studies of relatively acute shocks (Sabates-Wheeler et al. 2022).

The relative lack of permanent transformations identified in this study does not necessarily indicate that fishers in these communities fundamentally lack the ability to transform, should they see it as necessary in response to future shocks. People's experiences of responding to the pandemic, and observing the responses of others, even ones which were subsequently abandoned, may have been a learning opportunity which increased their awareness and understanding of adaptive and transformative options available to them in the face of future shocks, as well as their sense of self-efficacy. Indeed, the ability to use experiences to inform future planning and pro-active adaptation is itself part of adaptive capacity (Engle 2011).

Leveraging the six domains of adaptive capacity

We found that all six domains of adaptive capacity played a role in shaping responses. We found both that some domains were drawn on by more people than others, as shown in Fig. 2, but also that individuals drew on some domains more regularly than others to facilitate several responses. This was likely both a function of how helpful that domain can be and the level it was present in individuals and across the community. For example, we found that flexibility was the most utilised domain, and assets the least. This does not necessarily mean that assets are not helpful and capacity-building efforts should focus primarily on flexibility as the most useful domain. Instead, it likely reflects the overall low-asset base in the communities to begin with. There is significant evidence from both this research and the long history of capacity-building research and interventions that a lack of assets is associated with the adoption of maladaptive coping strategies, which create a negative feedback loop of diminishing asset bases and reinforcement of poverty traps (Dercon 1998; Siegel and Alwang 1999; Lemos et al. 2013), and having assets increases the likelihood of engaging in more long-term adaptive and transformative strategies vs. short-term coping strategies (Sen et al. 2023). Similarly, Lauer et al. (2024) found that instead of households with diverse livelihood portfolios thriving due to higher flexibility,

households who only engaged in fishing fared better than those who were engaged in both fishing and tourism prior to COVID-19 when the tourism industry collapsed and part-time tourism operators switched to fishing full time. The households who were always primarily fishers had more experience and specialised ecological knowledge, and were more successful than the previously part-time fishers, demonstrating that in that specific instance, the learning domain was more important than flexibility. It should be noted though that in the event of a shock which only impacted fisheries, fishing-only households would have suffered. Both examples highlight the importance of understanding how context influences the operationalisation of adaptive capacity, even in response to the same shock.

We also found that the different domains were associated with different kinds of responses. For example, flexibility, agency, and assets in particular were associated with transformations, and flexibility, organisation, and socio-cognitive constructs with facilitating or preventing coping strategies. These findings concur with previous research tying different domains with different types and levels of responses (Barnes et al. 2017, 2020; Green et al. 2021; Salgueiro Otero et al. 2022; Bartelet et al. 2023). Overall, these findings support the increasing calls for more multi-dimensional approaches to efforts to build adaptive capacity (Mortreux and Barnett 2017; Barnes et al. 2020; Green et al. 2021; Elrick-Barr et al. 2023).

Interactions

One of our key findings was the interactions and interdependencies between the six domains. In many cases, a lack of capacity in one domain significantly undermined the others, for example a lack of assets reduced flexibility where potential adaptations were contingent on inputs or capital. In other cases, high capacity in a particular domain enhanced other domains. For example, social networks increased access to assets, learning opportunities, and new livelihood options (flexibility). Both these processes demonstrate the importance of building adaptive capacity in multiple domains. Attempts to increase one domain while neglecting the others are likely to limit or even undermine its effectiveness, and conversely, investing in multiple domains may synergistically benefit the others (Thapa et al. 2016).

Interactions between some domains of adaptive capacity have previously been studied on an ad hoc basis. For example, Babcicky and Seebauer (2017) explored how social capital (organisation) interacted with risk perception and self-efficacy (socio-cognitive constructs and agency) to influence the ability of households to adapt to flooding; and there is an extensive history of research linking access to assets with livelihood diversity and other indicators of flexibility (Kassa 2019; Nnaeme et al. 2021; Bartelet et al. 2022). However, adaptive capacity research remains somewhat fragmented and theoretical (Siders 2019). As such, more complex interactions, particularly between domains which have previously been the focus of largely separate fields, are yet to be systematically explored and empirically tested. Our findings are an early step towards exploring the interdependencies between domains; but more detailed and systematic explorations of the mechanisms through which the domains interact in different contexts are a clear area for future research.

Limitations

There were some limitations to our approach. First, using interviews which focused on broad discussions of responses to infer the influence of different domains of adaptive capacity may have disproportionally highlighted some domains over others. Participants frequently explicitly identified links between responses and their relationships with their community and institutions, their assets, and the choices available to them, but were, for example, less likely to reflect on their mental frameworks and sense of agency independently and directly. This tendency does not necessarily mean the less-mentioned domains are unimportant. The challenges of analysing the psychosocial elements of adaptive capacity (i.e. agency and socio-cognitive constructs) relative to more tangible aspects like assets and social networks have been noted previously, and are likely why much of the adaptive capacity literature, particularly large-sample quantitative research, tends to overlook them (Grothmann and Patt 2005; Brown and Westaway 2011; Mortreux and Barnett 2017; Cinner et al. 2018). A more direct approach where participants are explicitly asked about each domain could elicit additional insight into the role of the more subjective domains. However, our approach did provide insight into how risk perceptions, norms around individual vs collective responsibility, and participants' sense of agency influenced responses. Additionally, it shows which factors participants consider to be important for their own adaptive capacity, and therefore what they would likely want from future capacity-building initiatives.

Secondly, although frameworks are useful for analysis and identifying specific targets for interventions, it can be difficult, and perhaps artificial, to assign specific actions to distinct categories and adaptive capacity domains. As our findings on interactions show, the six domains of adaptive capacity are highly interdependent, and it can be difficult to determine what factors were primarily driving particular behaviours, especially regarding the less tangible psychosocial domains (Brown and Westaway 2011; Cinner and

Barnes 2019). This makes it harder to draw conclusions about which domains need to be strengthened, and therefore to make decisions about where to invest limited resources. While a challenge for research, these fundamental linkages reinforce the concept that in practice, interventions which target one domain while ignoring or undermining the others are unlikely to be successful, but conversely, improvements in one area may also lead to improvements in others (Cinner et al. 2018). Further research on the interactions between domains is needed so we can avoid potential failures whilst leveraging potential synergies.

Conclusion

We empirically examined how people in coastal communities in Kenya drew on adaptive capacity during the COVID-19 pandemic. We found that people primarily engaged in coping strategies, with some incremental adaptations and few transformations. Whether and how people were able to make various responses was contingent on a variety of factors associated with each of the six domains of adaptive capacity and the interactions between them.

Our findings empirically demonstrate the importance of all six domains of adaptive capacity during crises and reinforce the notion that pro-active resilience building activities and future crisis responses need to take an integrated, multi-dimensional approach. Individuals, communities, and practitioners need to look towards the development of strong, supportive social networks; facilitating deep learning through the provision of information; and creating forums for critical thinking and idea sharing. They also need to develop diverse and sustainable livelihood opportunities, so people have the flexibility to make optimal choices; increase absolute and perceived agency; and shape cultural norms and risk perceptions to promote equitable, sustainable, informed decision-making. As global shocks increase, lessons from how people adapted during COVID-19, what aspects of adaptive capacity facilitated or prevented beneficial adaptations, and how the different elements of adaptive capacity interact with each other are ever more critical.

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Data Availability The data used in this study cannot be made publicly available because they contain sensitive information that could compromise the privacy of research participants. Anonymised transcripts of interviews may be made available on request from the corresponding author (SS).

Declarations

Ethics approval Human ethics approval for this research was obtained from the James Cook University Human Ethics Panel (approval numbers H8109 and H7603).

Conflict of interest The authors declare no competing interests.

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