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Perceptions of climate change, multiple stressors and livelihoods on marginal African coasts

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Abstract Studies of multiple stressors in Africa often focus on vulnerable inland communities. Rising concentrations of the world's poor live in coastal rural–urban areas with direct dependencies on marine as well as terrestrial ecosystem goods and services. Using participatory methods we elicited perceptions of stressors and their sources, impacts and consequences held by coastal communities in eastern Africa (Mtwara in Tanzania and Maputo in Mozambique). Respondent-informed timelines suggest wars, economic policies and natural increase have led to natural resource-dependent populations in marginal, previously little-inhabited lowland coastal areas. Respondents ($n = 91$) in interviews and focus groups rank climate stressors (temperature rise/erratic rain) highest amongst human/natural stressors having negative impacts on livelihoods and wellbeing (e.g., cross-scale cost of living increases including food and fuel prices). Sources of stress and impacts were mixed in time and space, complicating objective identification of causal chains. Some appeared to be specific to coastal areas. Respondents reported farms failing and rising dependence on stressed marine resources, food and fuel prices and related dependence on traders and credit shrunk by negative global market trends. Development in the guise of tourism and conservation projects limited access to land–sea livelihoods and resources in rural–urban areas (coastal squeeze). Mental modelling clarified resource user perceptions of complex linkages from local to international levels. We underline risks of the poor in

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marginal coastal areas facing double or multiple exposures to multiple stressors, with climate variability suggesting the risks of climate change.

Keywords Africa · Vulnerability · Multiple stressors, climate change · Livelihood · Adaptation

1 Introduction

Insights into how different societies, populations and components of social ecological systems may be vulnerable to climate change are emerging. Much of this discussion is now couched in terms of the potential for and limits to building adaptive capacity and enhancing resilience (Adger et al. 2005, 2006; Nelson and Adger 2007; Vogel et al. 2007; Ostrom 2008). There is concern that the world's poor, many in tropical countries contributing the least to climate change, are the most vulnerable and unable to adapt to the rising frequency and severity of extreme weather and climate variability (e.g., droughts and floods)—which have profound impacts on water supply, river flows, crop and fishery yields and health (Mirza 2003; Lamarre and Besancot 2008; Srinivasan et al. 2008).

Although Africans have coped with climate variability (Vogel 2005; Fraser 2006) Africa now ranks highly in terms of expected vulnerability to climate change due to its elevated poverty, which enhances climate variability impacts on climate-sensitive activities such as rain-fed agriculture (Boko et al. 2007). Southern African countries, e.g., face-enhanced climate variability and long-term change related to El Niño Southern Oscillations—or ENSO (Zinke et al. 2004; Eriksen et al. 2005; Kadigi et al. 2007; Todd et al. 2008). Climate models are of low resolution and largely uninformative at local African scales for the purposes of our study areas. According to some authors, the continent risks becoming a global food crisis epicentre (McCarthy et al. 2001; Biggs et al. 2004). The impacts of climate variability may be even further enhanced through synergies with local alterations of grasslands and marine ecosystems (Thornton et al. 2008; Wilkinson 2006). These changes in turn may lead to deterioration of human health and other trends with potential economic impacts at different scales (Metzger et al. 2006; Vincent 2007; Biggs et al. 2008; Linden and Hanson 2007). There is a critical need to investigate and illuminate how these multiple stressors may affect the ability of households and communities to respond to climate change, and how it will affect their ability to secure and sustain livelihoods, future well-being and life opportunities.

The analysis here presents an empirical study of multiple stressors in coastal regions in two African countries. Stressors are defined broadly to include a wide range of factors, including micro- and macro-level social and environmental changes (e.g., the spread of infectious disease, trade liberalisation), of which impacts can manifest themselves at individual, household and community levels as gradual or sudden shocks—such as drought, floods, AIDS, trade competition or currency fluctuation (O'Brien et al. 2009). The selected areas are significant due to the nature of the threats they face, and their increasing importance for human and economic development. The sites within them are undergoing rapid social, economic and environmental change. In particular, they face problems of degradation and loss of access to land and marine resources and ecosystem services. In the absence of detailed climate models and social–ecological data, this paper explores local perceptions of multiple stressors, and responses to them, for their potential value in showing how communities may conceive and respond to 'risks', as defined locally. Our study ranks the relative importance of climate amongst other stressors, and identifies

impacts on coastal communities' main livelihoods on land and at sea. The following sections outline the research approach employed in the data collection and analysis. Results from four study sites in Tanzania and Mozambique are also presented. We draw out the critical stressors, the role of climate factors and the implications of how these interact together and impact on livelihoods.

2 Research approach

2.1 Framing the research

Interactions between stressors can have unexpected outcomes for well-being and livelihoods, with implications for efforts to reduce vulnerability in development planning (O'Brien et al. 2009). Vulnerability is variously defined and demonstrated (for examples and definitions see Adger 2006; Eakin and Luers 2006; Füssel 2006), but recent studies in African contexts have highlighted a conceptual need to capture the *changing* nature of risks, contextual factors influencing exposure to them, human capacity to respond and why some people/groups experience negative outcomes from shocks or stressors more than others (O'Brien et al. 2009). Stressors and their interactions may be hidden, and spread across scales, leaving communities subject to risks of double or even multiple exposures to stressors. This means the impacts of stressor may be felt twice or more, through different pathways. Reducing vulnerability can start with an understanding of such exposure and sensitivity to stressors across scales, including differential impact upon social groups (Thomalla et al. 2006; Polsky et al. 2007). Inherent in this lies a recognised need to move beyond assessments of vulnerability based on linear relationships of processes and outcomes to consider *why* people are affected by and cannot cope with stressors, e.g., links between climate change and human diseases such as AIDS (Few 2007). The importance of both situational and contextual factors in configuring the local development environment in which people live is highlighted in earlier studies of multiple-stressors in southern Africa (Reid and Vogel 2006). This means the impact and responses to these stressors appear to be determined and mediated by a range of social, cultural, economic, technological, political, and institutional factors.

Our objective is to understand human perceptions and experiences of, and responses to, past and current environmental change and how these interact with other stressors impacting upon livelihoods. We look for signs of any common trends between our sites, including evidence of rising differential vulnerability between groups of people, locally or between our sites.

2.2 Study sites

Coastal communities in African are amongst those facing most pressure from inward migration, urbanisation, resource extraction, pollution and industrialisation (Moffat et al. 1998; Scholes and Biggs 2004; Biggs et al. 2008; Paulet 2008, unpublished report). We selected two eastern African coastal states, Tanzania and Mozambique, for our research (Fig. 1). Both rank highly in international vulnerability tables and face rising risks of impacts from a wide range of human and natural stressors (Brooks et al. 2005; Cutter 2008). In each country, we identified two research areas reflecting some of these trends.

We used local maps, and completed site visits and scoping interviews with local officials and resource users to further narrow down our search for research sites. Given the nature of our study we were interested in poorer coastal communities with reported or

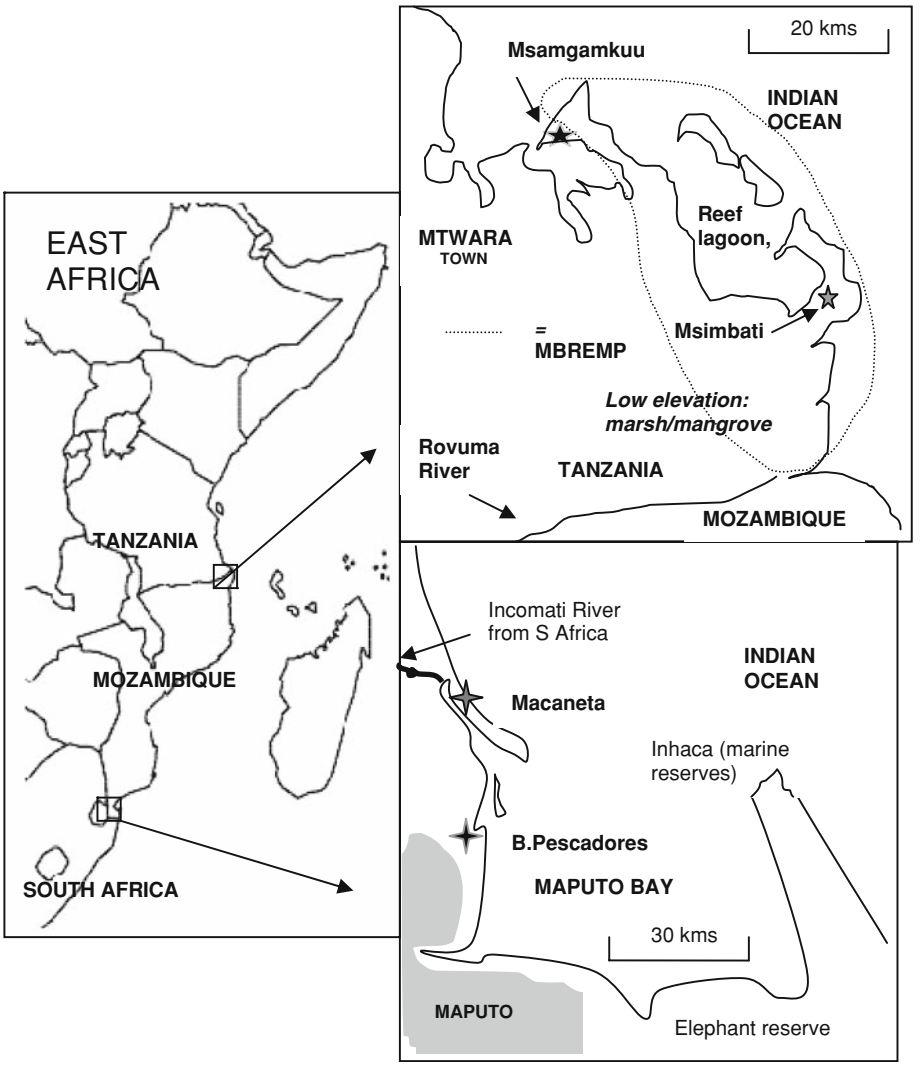

Fig. 1 Maps showing research sites (*stars*), including a Marine Protected Area (*MPA*) in Tanzania (*top right*, *dotted line* shows boundary)

evident dependence on marine as well as terrestrial ecosystem goods and services. As we also wished to include in our study the role of any climate variability and/or climate change amongst the potential range of multiple stressors to be discussed with communities, we aimed to select sites in low-lying coastal areas with geographical features (sand bars, sand spits) in proximity to lagoons, rivers and seas. This raised the potential for including factors such as river floods, droughts and storm surges. We included a mixture of urban and rural sites to include the additional potential impacts of development proceeding with urbanisation. Likewise, we identified sites that included nearby conservation interventions reflective of past or anticipated environmental degradation, including losses of sensitive biodiversity of ecological and/or economic value.

Table 1 summarises some of the characteristics taken into account during site selection. The selected sites include communities that according to local and official accounts have grown from small numbers of people in living memory (see timelines in "Appendix"), located in marginal areas, dependent on natural resources in confined rural–urban and land–sea coastal zone areas in proximity to new development and/or conservation projects. Two of the sites lie in peri-urban and outlying rural fringes of the national capitol (Maputo) in southern Mozambique (Bairro dos Pescadores and Macaneta). Across Mozambique's northern border into Tanzania, two other sites (Msamgamkuu and Misambati) lie in a historically poor part of Mtwara district. Together, these four sites comprise people in areas of two neighbouring nations separated by over 1,500 km, with different histories, cultures, environments, development and climates.

2.2.1 Tanzania

Mtwara District has a large cashew sector, with the local marketing board reporting significant exports to India by a major local buyer. Mtwara's main coastal port and surrounding area barely benefited from Tanzania's post-independence national wildlife tourism success. Past economic booms (e.g., post-World War II groundnut expansion) drawing internal migrants to the coast quickly collapsed, including socialist farm policies. Local officials report that a lack of infrastructure and cross-border military activities during Mozambique's war also deterred investment in southern Tanzania. Now, the Mtwara Development Corridor (MDC) project extends westward along the Ruvuma river border with Mozambique to landlocked states. Ongoing power and infrastructure projects are linked to hopes of greater activity in mining, agribusiness (cashews), livestock, tourism and other sectors. A new trans-boundary Marine Protected Area (MPA), the Mnazi-Bay-Ruvuma Estuary Marine Park (MBREMP) bordering the MDC (Malleret 2004), was gazetted in Mtwara in 2000. The 650^2 km park, including 33,000 inhabitants, covers 45 km of coast, with reefs, dunes, mangroves, wetlands, coastal lagoons, three main islands, and a large (Ruvuma) river estuary. A gas recovery project operating inside MBREMP feeds a new electricity power plant in Mtwara. MBREMP and MDC have implications for livelihoods and access to marine and land-based coastal resources. Local officials report that land allocations and relocations of resident people have started. Park managers confirm village protests against their project became violent, whilst tear gas has been needed at sea to enforce fishing rules.

2.2.2 Mozambique

Some similar patterns are apparent at research sites selected in Mozambique. The country's decades of colonial and apartheid-era conflict ended in 1992. It has rich land, marine and mineral resources, but the economy remains undeveloped relative to its natural resource base and many live in extreme poverty (UNDP 2003). This is changing, particularly around Maputo and other areas in proximity to the regional economic hub, post-apartheid South Africa. Reconstruction and development accelerated after Mozambique's national elections in 1994, with land law reforms widely seen as positive encouragements to foreign investors interested in projects from tourism, power and heavy industry to forestry, bio-fuel (e.g. sugar) plantations and mining. Tourism, with inward investment from South Africa and beyond, is amongst the sectors most rapidly expanding up and down the coast. Mozambique has Africa's longest coast, with major dunes, estuaries and banks for fisheries (Connor 2005). Maputo Bay has rare corals at Inhaca (Perry 2003) protected by the oldest

Table 1 Research site characteristics taken into account during visits for selection

Country	Mozambique		Tanzania	
Site (short ref)	Macaneta (M1)	Bairro dos Pescadores (M2)	Msimbati (T1)	Msamgamkuu (T2)
Population (est.)	150 (Hamlet)	5,000+	5,000+	4,500+
Rural/urban	Rural	Peri-urban	Rural	Peri-urban
Site characteristics	Exposed site on thin dune peninsular between river/sea	Semi-exposed site on coastal sand bar with mangrove back-lagoon and nearby river estuary	Remote, exposed headland site in low-lying area subject to tidal and storm floods	Sheltered coast with degraded reef platform
Access/infrastructure	Pontoon river ferry/seasonal road	Good coastal road	Graded road subject to seasonal rains/floods	Passenger ferry over bay, or indirect road
Main livelihoods	Fishing, petty trading	Fishing, petty trading	Fishing, farming, petty trading	Fishing, farming, petty trading, livestock
Visible degradation	River flood erosion, housing damage	Coastal erosion, lagoon infill for development, flood damage to houses	Coastal erosion, deforestation	Degraded coral reef platform, deforestation
Development	Tourism zone declared; nearby town (district seat)	Maputo industries, port and shipping, urban sprawl inc tourism	Nearby gas project and tourism expansion	Port with new development corridor plans. Cashew exports
Conservation	Land-based projects	Distant MPA across bay	Inside land–sea MPA	Next to land–sea MPA

MPA in East Africa. Although there is particular interest in reef coasts and islands nearer to the border with Tanzania (e.g. Pemba) construction is moving ahead in and around Maputo in areas easily accessible to local and cross-border tourists. Recently, large areas of south-eastern Africa were affected by severe and prolonged seasonal rainfall and three tropical cyclones between October 1999 and March 2000. Widespread flooding and damage to humans and nature was particularly notable in Mozambique (Christie and Hanlon 2001). This is linked in turn to rising government and donor concerns over future climate change (Patt and Schröter 2008)—at the time of writing under review by the government's national disaster agency (INGC). Mozambique's policies remain subject to foreign donor funds, assistance and influence, and internal political cordiality between the two political parties merging from the last civil war: the ruling FRELIMO party (Maputo strongholds) and RENAMO (Beira).

2.3 Data collection

We undertook a rapid exploration of local knowledge employing a number of different techniques which are described below. These approaches refer to Rapid Rural Appraisal, but extend to include the participatory construction of timelines and mental maps to contextualise, define and compare the stressors which affected people and their relative importance to different households. Such techniques have been applied in African and other developing country contexts to distinguish multiple stressors, their linkages, causal pathways, and relative importance (Abel et al. 1998; Cain et al. 1999; Ozesmi and Osezmi 2004; Lynam et al. 2007).

The data collection proceeded in five stages (Table 2), starting with exploratory interviews with a range of government, NGO, business and civil society organisations. These covered general contextual history (above), livelihoods, resources and governance (economic development, conservation, trans-boundary river water supply issues, and natural disasters).

Secondly, scoping interviews were held at the sites key informant elders and officials, who guided us through the research sites to identify general characteristics relating to livelihoods, living standards, infrastructure and physical vulnerability. In-depth interviews with two elders at each site to help ($n = 8$) us to build up historical reference points for

Table 2 Interviews and focus groups at each site

Research component/site ref: Mozambique/Tanzania	Site/sample size ($n = 91$)				Data collection
	M1	M2	T1	T2	
Entry and exit interviews with village leaders ($n = 8$)	2	2	2	2	ABF
Key informant interviews ($n = 10$): elders active in main livelihoods	3	3	2	2	AC
Focus groups ($n = 45$): male + female (age/wealth/livelihood mix)	m = 5 f = 4	m = 6 f = 4	m = 6 f = 6	m = 8 f = 6	CD
Household interviews: closed/open answer ($n = 28$)	5	7	7	8	DEF

(A), In-depth interviews; (B), village mapping; (C), historical timeline/ranking key social/environmental changes 1–5; (D), ranking change in livelihood/natural resources state; (E), stressor-source-impact/consequence tables; (F), mental models inc. using spider-grams

discussion and then further expansion in focus groups and follow-on household interviews. Based on these and the following research stages we established composite timelines for each research site to show the emergence of communities, locally observed changes and patterns in perceived stressors and impacts over the living memory of elders dating back to the 1940s in one case.

Thirdly, we selected the focus group participants ($n = 45$), including at least representative mixes of livelihoods, ages and differences in living standards (Hopkins 2007; Thomas et al. 2007). The small size of our sample precluded a statistically representative sample of each section of the community. We held focus groups separately for roughly similar numbers of men and women at each site. Participants were asked to identify and clarify key events and changes that had affected the community most, indicating the nature and source of stressors, and associated impacts and consequences. We fostered an iterative and inductive development of ideas, without mentioning climate change at early stages, and with open questioning to allow the development of both internal/external and socio-economic/biophysical issues. If unmentioned by the end of the sessions, climate was raised by us obliquely as an issue for the group to consider at the end. The focus groups then had an opportunity to reconsider all the issues together before ranking those identified as key stressors on a scale of one to five (decreasing importance), allowing basic site and country-level comparisons.

Fourthly, follow-on household interviews ($n = 28$) were used to further explore in detail and triangulate perceived sources, consequences and responses to environmental change. Respondents ranked (Likert scale) changes in livelihoods, natural resources states and overall quality of life (Bulmer and Warwick 1993; Sarantakos 2005) and influential sources of change (e.g. stresses and shocks, Turner et al. 2003). At the end of each interview, typically lasting 90 min, we asked respondents to summarise and clarify their responses again, so that we could assemble into guideline sequences what sources of stress lay behind perceived impacts and consequences (Blaikie and Brookfield 1987; Lynam et al. 2002, 2004). Resulting tables, showing loose causal chains, formed the basis of our subsequent mental modelling exercises. A total of 91 different interviewees were included in the main body of research outlined in Table 2.

For the purposes of our research, we defined mental models as qualitative representations of a system consisting of variables and the causal relationships between them (Ozesmi and Osezmi 2004). Mental models can allow explorations of issues that are not known for certain, and representations of perceived linkages and feedback loops that may be complex. Such methods can quickly capture different types of knowledge for informing policy processes, either in simple or developed quantitative forms with statistical values assigned to the linkages (Fuzzy Cognitive Maps). Mental maps or models have recently been used in rangeland and Sahelian contexts in Africa (Lynam et al. 2002, 2004; Tschakert 2007). We used spidergrams to assist in identifying components and linkages of the mental models. The tool often involves asking a central question (represented by a circle), to which respondents' answers can be represented by surrounding 'satellite' circles linked by a directional line of relationship. The satellite nodes can be the basis for the next question, and so on. Spidergrams are recognised for their usefulness in group/individual settings for developing discourse-based consensus on an iterative basis. Our focus on events and changes reflected our objective of drawing causal connections back in time and outward in space. This is recommended, e.g. in resilience thinking and event ecology, for capturing cross-scale social–economic-ecological factors and their complexity in ways that make social research more relevant to policy (Gunderson and Holling 2002; Walters and Vayda 2009).

In the fifth stage of our research, we took our findings back to key informants at each site to construct community mental models based on focus groups and household interviews. Throughout the data collection we used local government/NGO host translators fluent in local African and European languages (e.g. Portuguese/Swahili/Machangana). Fieldwork took place in April (Mozambique) and October 2008 (Tanzania). Focus groups and interviews were recorded when appropriate.

2.4 Research limitations

Our reliance on perceptions and the limited sample sizes in our small study raises some large questions over what we can reliably infer from our data, as does the initial reluctance of some respondents to discuss some issues (AIDS). Some key issues may well be absent from our data, and the objective truth of statements offered was not verifiable within the scope of our research. Our research was conducted in four languages, with risks of loss of nuance and time constraints cutting sample sizes. However, the issues and linkages that we do describe here were repeated in key informant interviews, our survey, participatory discussions (events–causes–impacts) and mental models. This degree of triangulation, we argue, goes some way to strengthen the validity of our data. Local official weather data obtained to potentially identify trends and notable changes comparable with perceptions suffered from large data gaps and differences in time series making this problematic beyond a few incomparable years.

3 Livelihoods and stressors at the sites

3.1 Livelihoods

At all sites, livelihoods centre variously on seasonal mixes of fishing, farming and petty trading typical in sub-Saharan Africa. At the Mozambique sites, respondents in interviews listed a total of 8 (Bairro) and 9 (Macaneta) livelihoods, higher than for Tanzania (Msimbati 6, Msamgamkuu 4). The differences are accounted for by the livelihoods of fewer people with less economic importance (e.g. security guard in city). Depending on the site, interviewees together said they depended on 8–10 ecosystem resources. These included seas, rivers, fish, shellfish, coral (Tanzania), trees (inc. mangroves), wetlands (Mozambique), grasslands, soils, and rainwater (for crops) and groundwater (potable).

Farming broadly involves typical food crops including rice, maize, millet, cassava, ground-creepers/nuts and table produce, with production shifting towards the more drought-resistant produce (e.g. less rice, more cassava). Beyond farm site selection and initial preparation of plots women complete most labour tasks at all sites, increasingly involving daily, weekly or longer migration using public transport to distant riverbanks and/or land of distant relatives. Farms were more expansive and developed at Tanzanian sites, where cashew and coconut crops provided additional commercial livelihood options for some beyond typical smallholder subsistence farming (notably Msimbati). Communities at all sites keep poultry and other livestock, including roaming goats in Tanzania and, in Mozambique (Macaneta), cows herded over river-bank wetlands less for consumption than as a store of direct and cultural wealth for local traditional chiefs.

Men at all sites typically engage in fishing in near shore areas (Mozambique), including reef lagoons (Tanzania). Fishermen in Mozambique rely more on skiffs, canoes and small sail/motor driven boats with limited-ranges, although outsiders operate large commercial

fishing and shrimping vessels in and beyond Maputo Bay. At Macaneta, fishermen switch between river (Incomati) and sea fishing, depending on the time of year, river and sea conditions and the weather. In Tanzania, dhows are generally larger and more sea-going than the fishing vessels in Mozambique, allowing access to distant coastal and offshore grounds, both to north in Tanzania and south across the nearby border with Mozambique. Overall, boat ownership appears to be higher in Mozambique, but Tanzanians work together on their larger vessels and have more backyard farm plots and access to distant farming areas, usually rivers with rich alluvial soils near to the water (cutting reliance on purely rain-fed agriculture. Women in both countries (in particular Msamgamkuu and Bairro dos Pescadores) glean over extensive tidal sand and reef flats for (declining) shellfish and/or octopus, with some (notably Msimbati) wading for sea cucumber destined for lucrative local and Asian markets.

Beyond the dominant livelihoods respondents mostly engage in various kinds of general trading (including water deliveries and beer production), wood cutting (hardwood species and mangrove), reed cutting (especially Macaneta), limestone kilning (Msamgamkuu) and house and boat building. Women at all sites prepare and market farm produce and fish catches. Women also dominate the selling of small-holder farm produce, the preparation of roadside food stalls and trading of general store food and other non-consumable household merchandise. In both countries, respondents buy and sell produce and goods from nearby towns and cities, where employment options were seen as desirable—although largely absent beyond low-paid, menial and occasional work (e.g., domestics, occasional building work and security jobs in Maputo). For petty trading, women (mostly) depend on unreliable and increasingly costly forms of public transport on dirt roads and tracks (rains/floods/erosion)—from tractors (Tanzania) to minibuses (Mozambique)—when not walking (all sites), cycling (Tanzania) or catching lifts from passing vehicles. A few local traders dominate larger local trades, e.g. cashew nuts and sea cucumber from Mtwara (Msimbati) subject (in principle) to regional Tanzanian marketing rules, restrictions and price-setting.

Overall, there is much similarity between sites in terms of livelihoods, but with local variation in emphases and ecosystem resources (e.g. coral). Limestone kilning highlights a typical pattern at all research sites of household dependencies on marine as well as terrestrial ecosystem goods and services. Trees felled on land are burnt in pyres under piles of coral blocks extracted forcibly from nearby reefs. This produces lime for rendering house frames frame-constructed from locally cut mangroves and thatched with grass and/or wetland reeds. Beyond the economic mainstays, wider development and conservation have advanced in areas of varying but close proximity to the research sites, all of which lie in coastal beach locations attractive for beach tourism and/or residential development. Tourism forms an important component of this trend. At Macaneta, South Africans investors are quickly developing tourism, striking deals with local officials, businessmen and traditional chiefs.

3.2 Changes over time

Overall, respondent accounts at our Tanzania sites suggest communities have been more stable than those in Mozambique, which have been established for shorter periods and with more ethnicities due to major internal migrations. Elders reported general tolerance of voluntary and enforced mixing of communities and ethnic groups at the coast. Elder key informants recalled how research sites in Mozambique arose from temporary fishing camps. During Portuguese colonial rule, people were encouraged to settle and fish at Bairro dos Pescadores in initially restricted numbers. Others migrating to and from South African

mines later settled in the area along with people looking for work in Maputo, which continues to this day with city expansion and integration of internally displaced people. Mozambique's colonial then civil wars, and parallel economic collapse, prompted migration not only to the capital, but also to remote, sparsely populated coastal fishing areas, such nearby Bairro dos Pescadores and Macaneta, isolated from much of the fighting by geography and limited tactical value. In (largely) peaceful post-colonial Tanzania, respondents recalled moving to remote southern coastal areas (despite cross-border mining of farm areas) more for economic reasons alone—for example, during failed colonial development booms (e.g. groundnuts at Mtwara) and failed post-colonial socialist farming policies inland. As in Mozambique, these disrupted market incentives to produce food, leading to dependence on the state (aid), notably in emergencies (droughts and floods). Even so, the majority of households in our study had relatives nearby, providing quickly exhaustible emergency pools of goodwill cash, credit, fish/produce and accommodation. Defining households was complicated by sequential marriages and/or polygamy. Respondents at our sites reported higher numbers of children in Mozambique (5–10) than in Tanzania (<5), and higher infant mortality, but available official statistics were too broad to confirm this at local scales. Men usually presented themselves as household respondents, notably in the Muslim areas of our study in Tanzania. They described how natural resources had come under greater stress, e.g. through the impoverishment of marginal soils in brackish water areas, or sub-division of land and a consequent lack of effective crop rotation.

3.3 Indications of stress

We asked household interviewees at all sites ($n = 28$) to indicate their general perceptions of improvement or deterioration in their (a) quality of life, (b) livelihoods and surrounding (c) ecosystem resources. Table 3 shows there responses using a Likert scale, with -2 showing the most negative statements and $+2$ the most positive. Respondents were allowed to refer to more than one livelihood or ecosystem resource. Household interviewees in both countries indicated overwhelmingly negative perceptions (-1 and -2) of trends in livelihoods (usually expressed as declining yields and/or income), and associated ecosystem resources together underpinning livelihoods and overall quality of life. Although livelihoods and ecosystem resources entered into quality of life perceptions, this wider issue also related to many other factors such as employment, public infrastructure and services, and other developments clarified in subsequent questioning.

4 Identifying and ranking stressors

Respondents in focus groups expressed similar views and discussed a broad range of social, economic and natural stressors and impacts, with timelines dating back to the 1940s ("Appendix"). We focus on stressors ranked amongst the top five for all sites. They include climate (with links, e.g., to trans-boundary river water fluctuation), illnesses, natural resource degradation (fishing, farming, deforestation), cost-of-living increases linked to global financial/commodity markets (fuel/food) and conservation and development driven largely by outsiders (international NGOs, governments, investors). We then expand upon these in later sections to illustrate how stressors are linked in respondents' minds to the perceived role of climate, aided by our source–impact/consequence tables and

Table 3 Changes in quality of life, livelihoods and ecosystem resources

Likert scale ranking	*n*	+2	+1	0	−1	−2
Livelihoods						
Bairro dos Pescadores	7	3	1	2	3	8
Macaneta	5	0	0	4	6	5
Msamgamkuu	8	0	0	0	2	9
Msimbati	7	0	2	1	3	9
Total	28	3	3	7	14	31
Ecosystem resources						
Bairro dos Pescadores	7	8	2	10	18	21
Macaneta	5	0	8	10	14	11
Msamgamkuu	8	2	0	3	3	17
Msimbati	7	4	5	8	16	30
Total	28	14	15	31	51	79
Quality of life						
Bairro dos Pescadores	7	2	1	0	2	3
Macaneta	5	0	0	0	1	4
Msamgamkuu	8	0	0	1	1	6
Msimbati	7	0	1	0	0	6
Total	28	2	2	1	4	19

Livelihoods cited: (*Tanzania only)—Fishing, farming, gleaning/beach fishing, backyard/distant farming, *commercial farming, wood/reed/*grass cutting, livestock, trading (general/fish/beer/stall), *builder, paid labour (farm, guard). Ecosystem resources: seas, rivers, fish, shellfish, coral (Tanzania), trees (inc mangroves), wetlands (Mozambique), grasslands, soils, and rainwater (for crops) and groundwater (potable)

mental models. Our initial interviews raised a wide range of perceptions of environmental change illustrated in Table 4.

4.1 Climate

When focus group respondents at all sites discussed their timelines and identified key issues emerging, they went on to rank climate-related stressors as the most important in terms of social–ecological change affecting their lives and livelihoods (Table 5). Perceived issues are included in the table if they ranked in the top five for at least one site (1 = high, 5 = low). The right column shows the relative importance of each issue in terms of its frequency of mention (maximum of eight: two focus groups each at four sites).

To consider the history of climate by site we referred in particular to elders' accounts (from interviews and focus groups) built into timelines. Younger respondents contributed to accounts of recent years. Although they cite different dates of onset, respondents generally perceive variations and changes in temperature and rainfall (often mentioned together as drought) as the main reason for negative changes affecting their lives and livelihoods. The perceived nature, severity and timing of these trends vary by site, as illustrated in the timelines. In Mozambique, climate was discussed by officials and villagers more in terms of change than in Tanzania. The onset of this change is dated earlier (1970s) than for Tanzania (1990s/2000+) although a possible intensification is dated similarly to an enhancement (intensity/duration) of a pre-existing and officially recognised four-yearly drought cycle causing droughts reported in Tanzania. In both countries, local

Table 4 Selected quotes illustrating change at the four sites

Fishers/farmers
In Europe we hear there is a lot of heat production so it comes down here and stops the rain. The weather change started in the (1980s, 1990s), and it has not ended
There is not enough fish…there are more people but the fish are also decreasing…fish have been declining since 1998 as the (sea) heat kills their eggs. We used to plan fishing by the wind but now it is disrupted
The soil is tired through overuse… (60% of population are internal immigrants)…government does not take care of agriculture sector…people were shifted (here))by force from the port area…we have to farm further away…monkeys (from inland areas of Sinde) are stealing our crops
We sell more fish to buy food instead of farming Until 1977 we could grow cassava (disease hit crops). Fish traders have to go further inland to get a better price
Before the marine park we could catch 3–4 tonnes in a day (peak season) but it is more like 1–2 tonnes. We were promised a lot of things (no sign of them). We refused to be in the park. It is political; village leaders sign even if people don't want it
There is not enough food for the community with people moving in (since the 1960s). People need land… more and more houses… and so the forest is being cleared. We even need permission to bury the dead!
Since 1995 prices (general) have started going up. Life got better (materially) after independence but now we are getting poorer again (with greater inequality). Development efforts have no lasting effect
MBREMP managers
Since 1998 the weather keeps changing. The duration of hight temperatures is increasing. It used to be wetter… Rovuma (river) floods (2006) destroyed many crops
Cashew is the driving force of the economy (with new cashew investor seeking 100,000 hectares) but other coastal livelihoods are now unsustainable. Most fisher use illegal nets
In near-shore fisheries there is unsustainable pressure on the coast. (The park) means people are now limited to the shore (don't have gear/technology for offshore fishing)… most fishers fish in the park when they can
There is a rising density of people, 30,000 people on a 40 km coast… rising migration due to the gas project…no infrastructure… one of the main threats is the high birth rate
Rainfall is quite variable with droughts and floods but I cannot state if it is more erratic. There has been some coral bleaching as the sea is shallow, but there has also been some recovery
Tourism adds to pressure. One of the primary issues is water supply
Women…most impacted. (Islamic) culture means they do most of the domestic and other work
Agric. official
The big change is rainfall pattern…not consistent. Upland crops most affected (shifting from maize to cassava)
Water official
… Fifty percent of (estimated) water demand is unmet). Droughts have been severe in 1980, 1984, 1992, 1998 and 5 years ago. (Rehabilitation of boreholes underway. Salt intrusion problems)
Fishers/farmers
The biggest impacts are coming from the natural world, not from the social world. The heat started rising (1980s) and animals and farms have since been dying. Fish rot quicker
Rains started to decrease in (1977)…problem is (partly) management of dams further up… more frequent…1–2 times a year. If the land is too wet the crops (e.g. cassava) rot
(In El Nino) causes the river width to shrink hugely. Sometimes freshwater sends our fish away. Fishing has been bad since 1985, so people have been cutting the mangroves (sell to Maputo)
The sea is coming into the river…because of the saltwater (rive) is no longer possible (to grow rice and other crops)… planting further away
With less rain we have to buy more things (seeds)… food prices are rising (reasons unclear)
Flood leaves us with malaria and cholera…government set up a medical post…that is now gone

Table 4 continued

It is good migrants came…. It meant they were saved (war) but it put pressure on (resources)

The village is getting…more children are born…not enough money to send them to school. The money has to come more from fishing. Agriculture gives no profit. Drought is the problem

We used to get 20 boxes of fish a day. Now you are lucky to get five, even if you night fish

Fishing (Bairro)…down in the 1990s…heat gets worse and the fish sanctuaries and homes have all been broken so we only get second grade fish (quality/size) these days

Outsider interests have more power. South Africans have the money. What do we know?

We were born as freemen. We don't know what will happen. Up to now no-one has come to help us. We don't own the future. There is no communication about what is happening

Fishing is not longer good so maybe it is a good idea in some ways (Macaneta)

Tourism

The water supply issue is going to haunt us in the future. The spring tides are getting higher That is why (river estuary and coast) erosion is so bad

The soils are no longer good for agriculture. We buy from outside. Dry spells…a problem and…wind gets up and move the sand (dunes). We will all pay the price…need to act together

District officials

The tax base is affected by the climate change…arising 10 years ago (?). All crops are affected

Temperatures here used to reach 32°C. Now they reach 37°C. The government can try to fight erosion but it will be a big disaster if it does not work

The population is rising rapidly. There is a problem with sanitation as much as water

The cost of living is rising (so) people are cutting wood for charcoal to sell (Maputo) for food

The sand bar (on which Macaneta is sited) will be uninhabitable if the river breaks through it

Table 5 Perceived changes at the four sites

Country	Mozambique				Tanzania				Total focus groups (f) citing stressor (Max. 8)
References	M1		M2		T1		T2		
Male/female focus group	m	*f	m	f	m	f	m	f	
Negative change and rank (1 = high)									
Rains infrequent/erratic	2	1	2	5	2	3	2	3	8
Temperature rising	1	1	1	–	3	1	–	2	6
Illness (human)	–	1	–	3	1	2	5	–	5
Food prices	4	1	–	4	5	–	–	–	4
New fishing rules/MPA	–	–	–	–	4	–	4	4	4
Floods frequency/severity	5	–	5	2	–	–	–	–	3
Wind direction/strength	3	1	–	–	–	–	3	–	3
Less fish catch	–	1	–	–		4	–	1	3
Poor trading (quantities/prices)	–	–	–	–	–	5	–	5	2
War impacts	–	–	4	1	–	–	–	–	2
Sea level/tide/surge	–	–	3	–	–	–	–	–	1
Population rise/density	–	–	–	–	–	–	1	–	1

* *See sect. 4.5*

citations of severe drought fall in periods of known ENSO events (1970s, late 1990s). Elders in Mozambique and Tanzania refer back to the 1970s as the onset of severe floods increasing in severity and frequency up to recent years' events. Water releases to local rivers there are partly controlled by dam operations in South Africa, which during apartheid negotiated terms now seen as unfavourable to Mozambique. In Tanzania, river floods are cited as a problem for distant farm plots only. In our timeline-building exercises, village elders at all sites refer to an increasing frequency and severity of such climate-related natural hazards, ranking them additionally to temperatures and rains. Villagers in Mozambique describe how vulnerable their grass-thatched huts were to other climate factors, including freak hailstorms powerful enough to smash huts and kill wetland reeds, let alone unsheltered people and animals.

4.2 Natural resource degradation

Respondents at all sites say they now have to travel further to farm and fish than in the past due to degradation of local farms and fishing grounds. Marginal soils and the presence of brackish water are perceived to have limited farming options at two sites from first settlement onwards and at all sites by 2000 as soils became 'tired'. Respondents report that as farms became less productive, sensitive crops fail first (rice, millet) until some farms are simply abandoned. Remaining farm plots are reported to have been abandoned increasingly since the 1990s. Respondents showed us disused plots and there were almost no other signs of proximate cultivation compared to sites in Tanzania. At Macaneta, soils are marginally sited near flood plains and in villages exposed on two sides to floods and erosion (sea/river), whereas at the Bairro dos Pescadores early settlers reported dividing and selling off land to family members and newcomers to the village for building, leaving little left for agriculture.

Similar trends resulted in less farming at all sites. Farmers have switched into largely unregulated fishing at all sites to cope with reduced harvests and related income from sales of surplus subsistence crops. The status of fish stocks in both countries is unclear from local and official reports in the absence of time series data but in Tanzania, in particular, local and NGO reports (e.g. Malleret 2004) suggest recent declines due to overfishing. Prominent fishers (boat-owners, respected people) at Macaneta (Mozambique) describe how the number of people fishing and boat numbers rose during the 1960s colonial wars, followed by a steep decline in per capita fish catch (1970s/1990s) starting during the long national civil war that followed. Increased fishing effort and fish sales at all sites are now needed to generate cash for shop food purchases, subject to lost fishing days due to (rising) unpredictability in sea currents, winds, state (waves) and fish stock movements reported by respondents in near and offshore fishing grounds. Bans on extensive dynamiting of reefs (for fishing and limestone kilning) there were introduced after NGO campaigns and in the late 1990s, and enforced after bomb attacks on US embassies (Tanzania and Kenya). Some target species are reported to have simply disappeared from waters shallow enough for gleaning. Women generally appear to be being displaced in the ambulant fishery sector and some marketing activities by men (in Tanzania) aiming to recapture income lost through declining catches. This is more important in areas with larger tidal flats such as Msamgamkuu and Msimbati, where there is a need to generate more cash to pay shopkeepers for food that in the past would have been grown locally. Water board officials for areas covering both cites reported notable water deficits on current trends, for Mtwara and Maputo.

4.3 Food and fuel prices

Respondents at all sites report declining farm and fishery yields, although some express this in terms of per capita yields and catch rather overall farm production or fish catch by their community. Again, there were no local or official data available to clarify this quantitatively. Respondents describe an increasing trend for skipping meals and going hungry due to a lack of cash to match their rising dependence on food purchased from traders or at shops. Food and fuel prices in the opinion of many respondents have been artificially inflated, exacerbating the impacts of global price rises trickling down to local levels with imports. Farmers and fishers travel further on a daily to farm plots and fishing grounds, whilst journeys to market and shops involved higher fares and fuel costs, with immediate impacts on disposable income and available labour time. Rises in transport costs lay partly behind Maputo's barely contained early 2008 riots after global oil and gas market price peaks added to local tariffs. The impacts of food and fuel prices was more strongly apparent in household interviews, in which respondents tended to discuss sources and impacts of stressors together unless requested to clarify any sequential order of causation. For example, whether prices were due to declining local food production or international market trends reflected in purchased food. Cash-crop farming as a flexible livelihood option was widespread only in Tanzania (cashew, coconut), where perceived declines are locally attributed to a more complex mixture of market, policy and climate factors including fungal attacks and drought mortality. Some cashew traders at Msimbati are still able to invest fisheries profits in farm maintenance, but even this was harder with falling receipts and outsiders increasingly dominating price-setting and contracts within national and increasingly international marketing chains.

4.4 MPA conservation and development projects

Respondents in both countries indicate that restrictions on land and sea use (inc. fisheries) related to conservation and development boundaries and rules have the net effect of squeezing more people into smaller areas—which we refer to here as a coastal squeeze. In Tanzania, the ambitious MPA conservation and development projects (MBREMP) is widely cited for its impact on local livelihood options through reduced access to land–sea areas and broken promises of assistance, e.g. boats/nets, to fish in other areas. This is only partly mitigated by larger fishing boats and even organised SCUBA diving teams allowing access to larger oceanic species and top predators in the marine food chain for sale into the local and regional markets. Park officials report that over 50% of inhabitants are under 15-years-old; raising risks of even greater unsustainability in future livelihoods. Due to port development some farmers have been moved, for little recompense, away from outlying Msamgamkuu farm areas to the village centre. Tanzanians and Mozambicans variously speak of development as potentially beneficial to them, particularly in sites in view of nearby urban centres, but few beyond petty trading expect benefits and some said the poor are priced out of urban markets and operate in the same areas and social strata as before. Residents report the creation of few alternative incomes in tourism (or gas sectors), although hotel demand for fish at Macaneta and restaurant demand near Bairro dos Pescadores could rise. In Mozambique (Bairro) and Tanzania (Msamgamkuu) there are limited options for village expansion. The urban fringe of Maputo, with wealthy gated housing estates and shopping malls, is rapidly expanding north up a thin and attractive coastal bar and a back-lagoon of floodable areas cleared of mangrove. Macaneta villagers were to be relocated beyond the Incomati River to a nearby district town with previously large war and flood

refugee settlement areas (Marracuene), to make way for South-African dominated tourism development. This includes a hotel under construction on a dune crest recently overrun by Incomati River floods. The floods damaged houses and farms in Macaneta as it by-passed the normal estuary route to the sea, eroding river banks and undermining hotel properties. At Msimbati, a small (outsider-run) beach hotel is to be joined by others. A toll gate at the beachfront of Msimabati collects park entry-fees from tourists to cover MPA running and enforcement costs, but park officials report minimal receipts.

4.5 Illness

Human illness ranked highly as a critical issue at all sites, especially in Mozambique (male and female focus groups) and was linked to climate change and related natural hazards (floods). Disease is linked by many to floods but also rising annual temperatures. High rankings of illness are a stress factor related to perceived rising incidences of both known and unknown illnesses (human and livestock). All sites report rises in malaria, AIDS, cholera, typhoid, diarrhoea and unclear new intestinal illnesses. Malaria nets (500,000) recently distributed by US-led aid programmes in the area tend to be used for fishing juveniles, with impacts on the wider fishery. Meanwhile, inward migration is associated with negative behavioural and cultural changes, reduced personal hygiene, poor village sanitation and rising vector resistance to drugs. These feed into perceptions of rises in disease. Women focus on illness more than men, for clear reasons. In Mozambique, women often corrected statements of numbers of children by subtracting those already dead, and frequent ceremonies surrounding interviews were suggestive of the wider daily death toll from all diseases. Women in focus groups at Macaneta failed to rank illness and other stressors separately, choosing in light of high child mortality to score all similarly highly in importance (1) due to their perceived inter-linkages. People did overcome an initial reluctance to discuss in full AIDS, with its links to other stressors and devastation in terms of death. Mortality rates were uncertain and village elders suggest few are still counting, inline with a lack of recent entries on street-side charts intended to show progress in combating diseases. Officials indicated 15–20% prevalence levels. Many people have no means to get treated—even if they could afford rising transport fares linked to fuel price increases and government tariffs.

4.6 Other stressors

Only climate factors were ranked in the top five most important stressors by focus groups at all sites. Respondents downplayed the impacts of headline events such as wars and floods. Memories of wars (which have ended) are fading and communities had in any case found refuge in coastal areas least impacted. Floods were seen as having quicker recovery times compared to ongoing yearly experiences of variability/change in rains and temperatures—cited separately or in combination as droughts with increasing (perceived) frequency at all sites. However, flood damage (erosion) was particularly visible at the sites in Mozambique. Both were in closer proximity to a major river (Incomati). Floods are linked closely to local and distant weather trends and dam operations, particularly in Mozambique. In Tanzania, floods were seen as a lesser, more temporary concern. Even so, officials recognise that dams envisaged to help electrify and irrigate the MDC could potentially lead to disruption of river flows to the sea. Rising sedimentation of the lagoon due to Ruvuma river outflows is seen as a risk to fisheries. Recent erosion reducing beach-frontage coconut plantations at the coast (Msimbati) is attributed to the 2004 tsunami and perceived tidal

Table 6 Ranking of events and changes

Mozambique ($n = 13$)	Mentions	Tanzania ($n = 15$)	Mentions
High food prices (rising)	11	Less fish	12
Less rain (infrequent/erratic)	8	Less rain	10
River floods (frequency/severity)	8	Rising illness	9
Rising illness	7	Food prices (rising)	9
Winds stronger	6	Low crop prices	6
Temperature rising/drought	5	Less crops	5
Less fish catch	4	Fewer jobs	5
Soil salinity (river)	3	Population rise/density	5
Sea flooding (tide heights/surges)	3	Soil depletion	5
Population rise/density	2	Lower fish prices (sell)	2
War	2	Less credit access	2

height anomalies since then. Alterations in the direction and strength of winds (notably cyclones in Mozambique) and sea currents (both countries) perceived by farmers and fishers are also cited as disruptive, leading to reduced access to fisheries and catch per unit effort. Freak hail storms in Mozambique are locally reported to be more frequent, with attendant physical damage to people, property and resources such as wetland reed-beds killed along the Incomati River. Otherwise, oil shipping (with spills) and development projects (e.g. new MOZAL aluminium smelter) have raised concerns over pollution in Maputo Bay. As industrial and agri-business projects proceed amid an urban population booms, there are also concerns over projected acute water deficits and perceptions of a need to build and complete dams to buffer river flows determined largely by the upstream dams in South Africa.

Villages visited were in a poor state, with damaged housing and wells, little infrastructure or public services and no shops. When household respondents ranked the principle stressors impacting upon their livelihoods they cited similar issues to the focus groups, but perceptions of temperature rises and associated drought were strongest in Mozambique. Householders focused more on specific changes in their livelihoods, with answers at first sight at variance with the focus groups consensus views shown in Table 6. These appeared to be less the case when we discussed their perceptions in more detail. Negative perceptions of trends in quality of life were lower in Mozambique, but there were some positive statements related, e.g., to new public services infrastructure (e.g., school, clinic and public standpipes at Bairro Pescadores), conservation efforts and switches into trading and urban livelihoods (e.g. security guards) as farming/fishing declined. Positive livelihood indications in Tanzania related to just a few fishers (Msimbati) with access to off-lagoon fisheries using nets promised to them for staying outside the marine park (MBREMP). Such promises have largely not been met and most others fishers were effectively restricted to degraded near-shore areas where MPA no-fishing rules are being enforced. The issues in the table are also expanded in Table 7.

Table 7 Householder perceptions of stressors, sources and impacts

Events	Sources	Impacts and consequences
Mozambique		
Food prices	Unsure; profiteering; population rise; farm subdivision for building; fuel prices; post-war socialist farm/food policy; climate change impact on young crops	Less income; increased beach fishing (women); fish and farm more to earn money for shop food; travel further to fish/farm/market; sell livestock/fish to earn cash to pay for food/schools; illness and death amongst local population cuts labour effort/effectiveness
River floods	Normal weather cycles; distant upstream weather and change; upstream dam management (S. Africa)/sugar irrigation (Mozambique sugar bio-fuels); lack of dams in Mozambique to buffer trans-boundary flow	Destroyed homes/arable area; erosion of farm land and fruit trees; abandon farms; switch between river and sea fishing; no seeds—need cash to purchase from shops; food purchases to replace subsistence crops; trade and food/water supply disruption (ferries, wells etc.); scavenge from house debris and bodies washed downstream from worse-flooded zones; illness and death of people, livestock, fish (although fish stock rebound can be positive)
Rain decrease	Change in nature AND cyclones?; "Maybe nature, maybe God"	Reduced fish/shellfish landings; rice and other farming area reduction; spoiled livestock grazing; human food shortages up to starvation; livestock disease/death poor growth (stress; malnutrition); forced purchases of food/water; build up food stocks; undertake more fishing; travel to wells and farm or fishing areas; hold more traditional African religious ceremonies; invest in smaller livestock species (ducks in floods)
Disease rise	Unsure, low awareness; less rain, floods; population rise; malnutrition; stronger winds bring disease—inc cholera; lack of hygiene; floods (cholera/garbage)	Loss of labour, income (fishing time); death of parents: less childcare/other social capital; healthy work harder; purchase food at shops; lack of funds—meaning reliance on traditional medicine/related plants
Winds stronger	Unsure; cyclone change	Human death, fishing accidents; debris damage to boats and nets; reduced fishing time/effort; damage to dunes means house damage Repair using local resources, spare parts purchases if needed
Heat, drought	Don't know; "Sky is coming down…"; "Made by God, comes and goes"; cyclone change; new aluminium smelter nearby raises temperature	Reduced fish catch; less farm produce; deterioration of fish means low prices from traders; illness and stress; reduced grazing/elevated livestock mortality: reduced river flow = means saltwater intrusion/crop failure; farm abandonment and shift to fishing and trading; distant farm plots higher food prices; food sharing, goodwill credit lines for purchased food

Table 7 continued

Events	Sources	Impacts and consequences
Fish catch down	War, less rain, rising temperatures (drought), floods, more people/boats/engines; lack of distinction between seasons; outsider fishers; shipping channel (Mozambique) oil spills	Less income; less food; change fishing practice, grounds and target species; switch from fish to prawns (using wrong gear); less boat-building; stay at home and do nothing; trade beer; borrow money; general trading; crime
Sea floods	Larger waves, tides: reason unknown. Coastal tree cutting	Damage to houses, crops, livestock. road and ferry access disruption; No action; use boats, longer routes to reach markets
Salinity (soil and river water)	Less rain, stronger wind; upstream dam impact; water off-take upstream (plantations inc. biofuel sugar cane)	Commercial and non-commercial plant/tree death; shrinkage of usable farm area; farm abandonment; more fishing contamination of wells for watering and limited irrigation; less fish/shellfish in river; reed-bed death
Population rise	War; natural increase, economic migrants; marriage	Less space for farming; less fish per fishermen (more boats/people); disease; erosion (tree-cutting for houses/fuel); trading; exploitation of more resources
War	Population rise leading to building and more tree cutting (mangroves). No longer applicable—wars over	Destroyed farms, less farm area; move to coast to fish, hide on islands or move out as fighting approaches; more fishermen, less fish; erosion, saltwater intrusion; unemployment impacts on natural resources
Livestock death	Heat stress and illness from eating wrong plants	Loss of food, sales income; fishing effort increase; Invest in poultry (ducks good in floods); fish more
Cyclone change/hail	Natural rhythm; don't know; climate change	Physical damage to houses infrastructure and farms; repair and replant
Sea level rise	Unsure; coastal mangrove cutting	Less fish; fish nets no longer reach sea-bed; coastal dune damage; change nets or fishing area when possible
Tree cutting	Population/poverty; fuel prices; boat-building; house and other repairs after natural hazards	Erosion (river and sea); reduced fishery landings (fish, shellfish); Follow NGO conservation advice; buy market charcoal, wood
Livestock roaming	Rules no longer respected; No rains for grazing	Crop loss; hunger; farm abandonment; switch to fishing, or fish and general trading
Tanzania		
Less fish	God's plan; population up (inc migration); outsider fishing vessels (inc foreign); climate variability/change; conservation policies and resource use rules/bans cutting off access/markets (MPA); coral and other habitat destruction (limestone)	Less income, lower living standard; less capital for farm capital and labour investments; less repairs to housing; rising fishing distance (inc Mozambique); illegal and night fishing to cut fuel use; underwater SCUBA drive fishing; reliance on shop food farm more; petty trading; credit unions); employee labour; malnutrition/illness

Table 7 continued

Events	Sources	Impacts and consequences
Less rain	World "ending"; natural four-year drought cycle (but extending); deforestation for farms, fuel, housing (and burning coral in limestone kilns); rising temperatures	Fish reproduction down; stocks move offshore (cool); fewer octopus; less potable water; go further to wells/buy water; farm distant river plots; farm decline; shift to drought-resistant cash/food crops (groundnuts, coconuts, beans) from cashew, millet, maize. cassava
Rising illness	Water quality declining (rain); behavioural change/contact with outsiders; resistant illness strains (malaria); dietary change (processed food); govt anti-malaria spraying stops; contraceptive pills make women "weaker"; AIDS	Bills unaffordable; less work/productivity/family income stability; negative impacts on other ill family members; no action—rising debt
High food prices	Population rise/farmland subdivision; local market politics—less govt food reserves/rising tax; global markets—oil and other fuel price inflation; poor exchange rates (Tanzania Shilling/USD)	Hunger; illness; crime; down-shift type of purchases; sell livestock; simple vegetarian diet; save money for purchases; shift into trading (women in credit unions); plant vegetables in rainier areas
Low crop prices	Over-specialisation (cashew/coconut); national market restrictions; trader tactics (government prices); cashew fungal disease; less credit and loans for inputs/farm maintenance); cross-border trade restrictions; poor information	Falling production and incomes; hunger. local economic decline and disinvestment; deterioration e.g. housing repairs; less farming; switch to fishing and trading if possible
Less crops	Less farmland—population "squeeze" from migration, town expansion (6,500 ha port) and MPA; plot subdivision; soil "dead"; farm input costs up; livestock roaming (crop damage); "Island" isolation; poor road access; youth disinterest in farming	Falling production and incomes; local economic decline and disinvestment; deterioration e.g. housing repairs; food and general price rises; greater fishing effort to cover shop food purchases; hunger;; invest in goats; switch to fish/farm/general trading (credit unions); switch to farming along distant rivers (nearby wetlands dried up permanently); rely on food aid; slash and burn more to raise productive area
Fewer jobs	Post-colonial decline (Mtwara groundnut and sisal schemes); railway/shipping decline; population rise; MPA restrictions; large projects (gas) use outside labour; lack of credit/government loans; tsunami/coast erosion	Marginal people and migrants suffer most; crime, poverty; cross-border legal and illegal trade in natural resources and general goods; new cross-river bridge diverts trade from area; rising debt; petty trading and cooking, door-to-door fish/crop sales; migrant fishing voyages; little action—unemployment; legal/illegal cross-border trade
Population rise	Govt healthcare policies (natural increase); youth "attitudes; family breakdown; unemployment; economic migrants—gas project and Mtwara development corridor	Unemployment, wage pressure; inability to support big families (breakdown); housing and land demand; pressure on fishery; water scarcity (people, livestock); food price rise; trading; aid; migrant work pattern; seek paid employment farm, boat, development projects)

Table 7 continued

Events	Sources	Impacts and consequences
Soil depletion	Deforestation; less crop/land rotation (population); climate change	Farm and income decline; hunger; fish more; shift farming to new area (inc distant riverside plots); try to get fertiliser (shortages, traders withholding stock after payment)
Low fish price	Poor market facilities (site and refrigeration) and access (ferries, poor roads); market relocation, trader tactics; reliance on ferry access (poor roads); low economic development, disposable income	Quick sale or deterioration; trader profit increasing from rising fish prices inland; no action; cut costs (night fishing); illegal fishing practices; sell direct in cities if possible (increasingly hard)

5 How do people perceive links between stressors?

Overall, respondents described a 'vicious cycle' of resource degradation and food insecurity exacerbated across scales by climate and global food and fuel price-rise trends. Respondent accounts testify to the complexity of interlinked stressors and their shifting nature over space and time. These commonalities extended across rural–urban interfaces and borders, subject to varying emphases. We illustrate the case of Macaneta (Mozambique) in Box 1.

We asked respondents through repeated and circular questioning to clarify their thoughts and answers in ways that would help us establish at least loose causal chains of perceived stressors, sources, impacts and consequences. Although such categorisations involving feedbacks were problematic, they were partially clarified through the subsequent mental modelling exercises. Issues relating to climate, food and fuel prices, with their roots in global processes emerged strongly as critical problems for local people. Such interactions between multiple stressors across scales and leading to local vulnerabilities have been conceptualised as three forms of 'double exposure' affecting processes, outcomes and responses (outcome, context and feedback double exposure respectively; O'Brien et al. 2009). However, we stress the difficulty in vulnerability studies of capturing for analysis an open-ended number of interlinked variables, of which an unknown number may be hidden. Householder perceptions of sources, impacts and consequences of change by country are summarised in Table 7.

5.1 Mental models of livelihood stressors: the role of climate interactions and impacts

Mental models developed individually in interviews and collectively in focus groups further elaborated how local people perceived linkages between stressors and impacts. In Fig. 2a, b we give examples of community-level mental models, and in Fig. 2c we give an individual model drawn with key informants and validated in focus group discussions. These exercises enabled us to probe more deeply and in some cases respondents only raised what they consider to be important issues at these stages. Together, the tables and mental models show that although similar climate and livelihood-related resource changes were ranked highly in both countries, their inter-linkages with other variables again tend to be more site-specific and varied in their spatial and temporal spread. In the case of all sites,

Box 1 Climate and river dam impacts on downstream fishing/farming livelihoods (Macaneta)

Macaneta's population has fluctuated with war and economic migration, whilst its future is linked to demand for natural products (fish, wood, reeds) and tourism. Head fishers at Macaneta (Mozambique) describe how the number of people fishing and boat numbers rose during the 1960s colonial wars, followed by a steep decline in per capita fish catch (1970s/1990s) starting during the long national civil war that followed. Climate change (rain and temperature) is perceived at Macaneta to have played a part in the degradation of farms and fisheries. Remaining farm plots have been abandoned increasingly since the 1990s. Climate impacts are felt through synergies with many other factors. Residents partly attribute their livelihood decline to the impacts of upstream dam operations in South Africa, which exaggerate river-level highs and lows during droughts and floods. During droughts, sea salt-wedges advanced further up the Incomati, reducing river-side farming (rice) due to salt-water intrusions acknowledged by local officials for killing reed-beds regulating flood impacts. In flood, the Incomati recently broke its banks and flowed over the top of the visibly eroded coastal dune crest at Macaneta, cutting village access routes. Trading and fishing by men (beyond gleaning) was badly affected, as fishing decisions (sea or river) at Macaneta relate partly to seasonal river heights, salinity and fluctuating sand-bar locations at the Incomati mouth. River floods brought negative impacts upon the fishery beyond any short-term benefits linked to inputs of freshwater favourable for fish juveniles. Women could trade less farm and fishery produce to buy shop food and had become indebted to other traders including shopkeepers, but less credit is available since recent global financial crises. To avoid hunger, men and women are travelling further to farm and fishing grounds, subject to infrastructure damage and small boat ranges. Rising illness at the site is attributed locally to malnutrition and typical African diseases (cholera, malaria, typhoid, AIDS), with cholera, for example, rising during floods as debris and corpses floated downstream from upstream areas. Where the Incomati meets the sea above Maputo in Mozambique, fishers refer to sea-level rise perceived through their own long-term observations of sea-water levels against ship channel marker posts. They blame such sea-level rise for observable erosion of Maputo Bay coasts and islands, with recent storm surges flooding over the coastal bar to damage houses and farms in nearby Bairro dos Pescadores for the first time in local memory. As traditional livelihoods decline, river bank erosion threatens the future of existing hotel operations next to Macaneta. Macaneta residents are to be relocated to make way for new South African-backed hotel investments. Even so, sea-level rise was generally mentioned as an ancillary stressor after changes in rain and temperature patterns. Upstream migrations of revered hippopotamus due to salt-wedges advancing further up the river each year as a function of climate, dams and water off-take and sea-level rise reduce scope for wildlife tourism in the area as well as traditional hippopotamus ceremonies

mental models revealed clear linkages between climate and degradation of ecosystem resources underpinning livelihoods. These in turn were linked to the stressors described in more details in Sect. 4. Climate change affects fishing directly, or through secondary routes such as river flow changes from distant dam operations related to South African rather than local water needs. A balance between river and sea fishing at Macaneta appears to have broken down as a result of climate, dam and soil fertility loss acting in synergy. The many climate-related changes in fishing conditions at sea beyond rain and temperatures could only be taken at the fisher's word in this study. Global fuel prices trickling down into local outboard motor running costs, together with marine parks cutting access to grounds meant household hardship was increased over and above purely climate related impacts. The legacies of past events and policies (wars and socialist economy) leading to rising populations partly created the conditions for dependence on marine resources seen today. In other words, climate stressors are mediated and interact with site-specific characteristics to produce different impacts and different patterns of responses. Local cultural issues (e.g. the jealousy of people improving their lot through boat-building) underline the local nature of elements of vulnerability at Macaneta. Together our mental models usefully help clarify the circular synergies and feedbacks in these linkages in addition to the more linear relationships and repetition in our tables of source–impact–consequences tables. Although

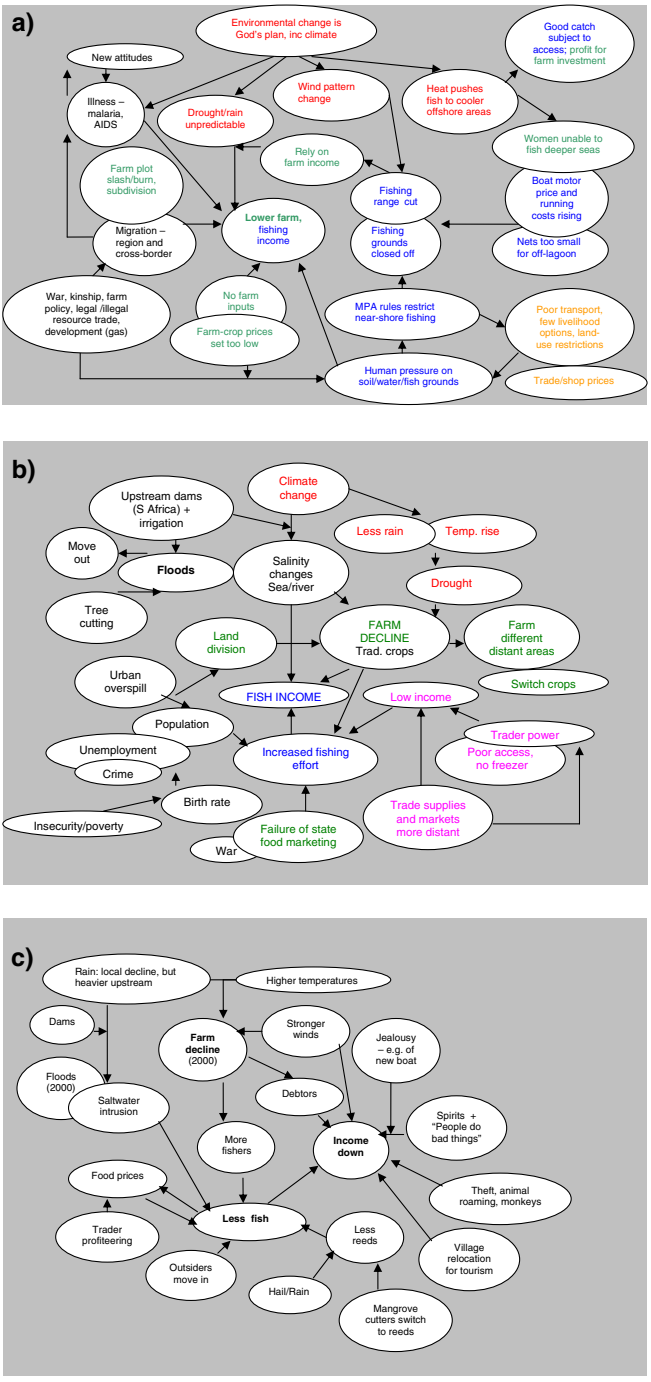

Fig. 2 Mental models of stressors including climate impacting on livelihoods. **a** Key informant validated mental models for Msimbati (Tanzania) and **b** Maputo (Pescadores). **c** Individual fisherman's mental model for Macaneta, Mozambique

we do not expand in detail on the usefulness of our spidergrams, here they were instrumental in clarifying respondents perceptions contained in the mental models.

5.2 Summary

The accounts of people living on eastern African coasts suggest they are exposed to old and new multiple stressors, and appear to be becoming more vulnerable to their impacts depending on the site. Vulnerabilities appeared to be emerging as stressors intensified. Focus groups at all sites ranked climate variability and change most strongly and linked it to ongoing water shortage, food shortage, disease (human, crop, livestock), farm and fishery decline, dependency on shop purchases/credit, and livelihood activities in distant areas. In some instances, people may be substituting one set of stressors for another, at which point the historical context appears to be highly important. People moved into marginal and limited areas with increasingly degraded ecosystem resources, even before current conservation, development and urbanisation pressure. Degradation in Mozambique sites appeared to be more entrenched, with options for farming compared to fishing highly constrained. Perceptions of climate change were more pronounced there and it is conceivable that even small changes in climate could have rapid and larger impacts beyond crop failures and farm abandonment. Fishing faces perceived negative change due to climate, meaning climate impacts may be felt twice, on land and at sea. Women appear to be highly vulnerable as farms have suffered most, whist their access to near-shore let alone offshore fisheries is constrained or minimal. They also face more immediately the impacts of illnesses related to climate (child death, lost farm labour and according to their accounts reduced income).

6 Linkages and synergies between climate and other stressors

Our analysis highlights a wide range of stressors affecting coastal communities and the cross-scale nature of impacts on local livelihoods and responses (Reid and Vogel 2006; Fabricius and Folke 2007; Thomas et al. 2007; Paavola 2008). Related studies in and beyond Africa also show how individuals affected by global environmental change are rarely responding to a single source of stress at any one time (e.g., Eakin and Wehbe 2009; Eriksen and Silva 2009; Eriksen and Watson 2009; O'Brien et al. 2009). These studies suggest that stressors identified in our study are not unique, including issues of climate variability and/or change, drought, market volatility, health, declining soil fertility and poor or absent public services. However, some may be specific to coasts due to their geography, dependence on marine resources at risk from climate change, and proximity to the large meg-city urban areas now associated with the world's coasts, including in Africa.

There are clear risks of people failing to cope yet alone adapt to multiple stressors, as reported elsewhere in southern Africa in livelihood terms (Ziervogel and Calder 2003; Eriksen et al. 2005; Reid and Vogel 2006; Ziervogel et al. 2006; Eriksen and Silva 2009). Similar risks have been reported for savannah communities inland (Eriksen and Silva 2009), where climate change risks are already enhancing the economic marginalisation of vulnerable groups such as women small-holders in Mozambique and Kenya (Eriksen et al. 2005; Gotschi et al. 2008). However, it is possible that in future more people will migrate

from inland to the coast, and then along coastal rural and peri-urban areas as such pressures grow. These areas, including cities, require more study. Where people had reached the coast we noted rising risks of overspecialisation in artisanal fisheries at our coastal sites, as seen in rural Asia and elsewhere (Coulthard 2008). Such shifts in coping strategies towards marine resources and livelihoods are reported widely in Africa, and extend to fish stocks, reefs, mangroves and other sources of ecological goods and services. Stressed communities often shift out of farming-related incomes (Eakin and Wehbe 2009), but at our research sites people had few options to turn to despite growing development and conservation efforts (mainly in Tanzania) and nearby urban growth (Mozambique and Tanzania). The extent of hardship and suffering was immediately evident upon arrival at most sites. As in other studies, rising fishing, farming (and trading and marketing) distances appeared to harm typical livelihood options and raise vulnerability to local-global fuel and transport cost hikes (Arndt et al. 2000; Hand and Mlay 2006; Gusdorf et al. 2008). The need to travel further on land or sea can be symptomatic of resource decline in southern Africa, including Mozambique (Lynam et al. 2004). Such coping patterns, if persistent, may be demonstrative of rising vulnerability (Eriksen et al. 2005). The ferocity of Maputo's early 2008 riots may have been an expression of this after transport subsidy cuts were announced at the same time as inflationary food and fuel price rises suggested food and livelihood insecurity.

There are risks of further reduction of critical small-holder farming and fishing livelihood options along on Africa's coasts, as evidenced by other regional studies (Reid and Vogel 2006; Mangi and Roberts 2007; Perry 2007; Thomas et al. 2007; Pratchett et al. 2008). The convergence of climate variability and dam operations affecting growing populations in downstream areas underlines such risks. Water availability emerges as critical issue limiting prospects for long term adaptation, in as much as it directly shapes food and livelihood security (Milman and Short 2009; Kadigi et al. 2007). Water scarcity, rising salinity and sea-level rise together pose risks of saltwater infiltration of coastal aquifers in our study as they do worldwide with sea-level rise (Melloul and Collin 2006; Gine and Perez-Foguet 2008). There is a need for greater understandings of the uncertainty about marine and terrestrial social–ecological interactions (e.g. change in coastal currents and fisheries interacting with estuarine systems), in rural and urban areas, and the mechanisms by which climate change may be manifested amongst other multiple stressors in these areas. There is a risk that if persistent droughts, erratic rainfall and rising populations continue, individuals or whole communities may be forced to import from or migrate to other areas to find the ecosystem goods and services upon which they depend for their lives and livelihoods. The recognised risks of rising vulnerability from upstream to downstream areas in river basins seen elsewhere in Africa is recognised and it is reflected in our findings.

Our analysis highlights the risks of policy adding to stress. For example, Marine Protected Areas have a mixed record in East Africa (McClanahan 1999; Sobhee 2006; Klein et al. 2008). As on land, balancing biodiversity conservation and development at sea using MPAs is problematic when large numbers of people with few livelihood options are involved. MPAs often have immediately restrictive impacts on coastal livelihoods, whilst taking time to deliver improvements in ecological goods and services underpinning existing or new livelihoods. The prospect of communities in our study being sidelined or relocated during development of MPAs was clear and underway.

By focusing on human actions causing environmental change and investigating historical and remote causal influences (and chains) our study reflects the aims of other researchers (Blaikie 2008; Gunderson and Holling 2002; Walters and Vayda 2009).

Isolating the impacts of African climate variability or change from other multiple stressors on livelihoods over temporal and spatial scales remains problematic. Given that climate models do not deliver a clear and consistent message about future climate changes for Africa, the complexity of linkage between climate and others stressors risk feeding into risks of cascades of uncertainty cited with respect to climate change impact assessments in national and more local adaptation decisions (Jones 2000). Just as climate science has moved on from deterministic probabilistic projections, perceptions of multiple stressors could be taken into more detailed future research on how people are likely to react to climate variability and change under varying future assumptions. Mental modelling could help clarify social ecological complexity in this process.

7 Conclusions

Our study shows the high importance attached by communities in Mozambique and Tanzania to climate variability and/or change as a stressor and threat to their livelihood(s). This factor was ranked highly in communities at each of the four sites we studied. However, climate stressors interacted with other stressors and generally had negative and sometimes synergistic impacts on individuals, households and communities. These experiences are in line with other expressions and analyses of 'Double Exposure'. The cross-scale nature of the stressors and the exogenous changes fuelled by global processes (e.g. price hikes in fuel and food) are notable, as are the slower more gradual changes such as those caused by disease and poor health, especially HIV/AIDS. The storylines or narratives developed from timelines and interviews indicate that coastal communities in these four sites are becoming more vulnerable over time. Mental modelling exercises reveal that people recognise linkages and feedbacks between events, processes and causes. In many instances policy is adding stresses or undermining peoples' ability to respond to change, and in these sites the control of water flows in upstream dams, and the designation of conservation areas, as well as expansion of urban development and tourism are critical factors. It seems likely that as coastal regions in Africa continue to attract migrants, and as land and marine ecosystem services are degraded, then the risks to urban and rural livelihoods from climate change will be further amplified.

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Appendix

See Table 8.

Table 8 Community timelines of events/changes in Mozambique (Macaneta; Bairro dos Pescadores) and Tanzania (Msamgamkuu; Msimbati)

Date	Macaneta: in Marracuene district north of Maputo (Mozambique)
1940	Rain/river fed farm produce stable and diverse: rice, maize, manioc, beans. No upstream dams in S. Africa
1963	Temporary fishing camp becomes permanent village on Macaneta peninsular (3 boats). Water is potable
1965	Tourist hotel established at Macaneta estuary (Incomati river ferry link). Fish demand rising
1973	Independence near ('75). Fishing boats increasing at Lhanguine (Marracuene town fishers). Catches "good"
1977	Evacuation after flood (S. African dams disrupt flows). Rains/rice down, water salinity up. Peak fishing
1983	Civil war (FRELIMO and RENAMO). Internal migration puts pressure on coastal fishing and farming resources
1984	Severe cyclone: property damage, fishing boats lost, seawater wedges moving further up estuary. Flood severity rising?
1985	War closes hotel, disrupts livelihoods. Refugees take refuge on coast
1992	Peace. Drought, rising annual heat. Out-migration. Farming/fishing slumping. Communist food marketing inefficiency
1993	Flood severity rising. Fishing boat numbers falling. New transport links (tractor taxis to ferry) improve well-being
1997	Floods (disease). Dams/sugar farms disrupt river. River saltwater intrusion notable. Residual rice failing. Rain deficits?
2000	Catastrophic floods to north. Incomati River floods/erodes banks (death, disease). Illegal fishing up around research sites
2003	Severe cyclone (district officials date climate changes to this time). Sanitation problems rising, cholera
2006	Tourism: official priority. Village chief signs deal for village relocation of 53 families in way of S. African hotel plans
2007	Village farms abandoned. Theft increase. Animals roaming eat remaining crops. Dependence of fishing (cash for food)
2008	Food/fuel shortages, price rises. Riots over food/fuel (Maputo). Annual heat abnormal, drought/hail. Shark fishing up
Date	Bairro dos Pescadores: fishing village in northern peri-urban Maputo (Mozambique)
1954	Plenty of fish in Maputo Bay. Migrants from all provinces arriving (some forced) in barely populated area and learning fishing European skills from Portuguese soldiers. About 13 boats. No roads
1955	Sea-level rising (local perception measured against navigation light pilings). Inhaca island (Maputo Bay) was "bigger" than in 2008. Local Xinfina island (prison island now used for fishing camps) was bigger, less eroded (broken in half)
1960	Uneventful years—good fishing quality and quantities. War against Portuguese (1964) gathers pace
1969	First signs of local fishery decline (still only 8/9 boats with no sails). Sea temperature rising. Sea level rising?
1970	Big cyclone. Apartheid-era migrant work to South Africa mines: local recruitment office opens (with official state-state revenue for Mozambique). Opportunistic migrants see and settle in area—add to fishing expansion. Large cyclone. Fish quantity and grades (3) start declining

Table 8 continued

Date	Bairro dos Pescadores: fishing village in northern peri-urban Maputo (Mozambique)
1973	Independence. Portuguese leave. Greater than 20 fishing boats. State (communist) food and marketing policies begin to have bad impact. Coop food production/distribution poor. Rainfall decreasing—long-term trend (starts in El Nino). Fishing boats increasingly destroying distant fish spawning grounds.
1977	Massive flood. Rising hunger. Less fish. Boat range extending/cooperative boats initiative (fibreglass/motors/sails). Localised fighting against Rhodesians (1974–1980) remains distant
1982	Massive arms dump explosion. South Africa ups support for rebellion.
1983	War. Crime. Environmental destruction inland. Migrants flow south and to coast. Droughts severity increasing/farming harder. Migration to S. African falls as S Africa backs RENAMO rebellion (inland Mozambique). Population rise fastest as migrants/refugees seek coast refuge. Fishing rising (50 boats)
1990	Temperatures rising, less rain. Continues up to present with negative impacts on farming and fishing. Farmers selecting drought-resistant crops (e.g. cassava, beans)
1991	RENAMO raiding Maputo fringes; villagers flee at night. Lose relatives and property/food. South Africa wins favourable transboundary river flow rates in deals ahead of peace
1992	Peace. Post-war investment boom starts. Demob fisher expansion. Mine recruitment in South Africa restarts. Economic migrants buying motors/boats in South Africa for local use. Fishery less productive. Food prices rising due to poor state marketing policies. Oil spill off Maputo Bay hits fishing for 2/3 years. Farming suffers from input shortages. Crime up
1997	New land tenure laws passed for development, resettlement of destabilised/uprooted population
1998	High temperatures and drought hitting farms. Dam flow decisions in S Africa exacerbate impacts (Incomati)
2000	Massive floods (2 metre depth), damage/erosion/roads cut). Locals seek refuge on roofs/ unaffected neighbouring Maputo. Urban population/land squeeze—proliferation of fishing boats (222) as poor settle on developing Maputo fringe. Few jobs. Rain decreasing fast. Drought feared more than floods. Women shifting into (ambulant/gleaning) fishery in large numbers
2002	Post-flood fish recovery. Govt assistance rekindles fishery, with lost boat replacements. Post flood cholera and malaria accelerate. Natural water drainage disrupted by population/development. Lagoon in-filled for wealthy malls/houses
2003	Aids death acceleration. Shrimp fishing wrecking benthos/fishery. Population pressure continues growth—migrants and natural increase
2004	Land subdivision from city encroachment and migrants starts having serious impact on farm productivity. Lack of farmland forces distant cropping. Shop food purchases rising sharply. Water pressure becoming acute. Fishers increasingly fishing camping on opposite side of Bay near new land/sea conservation areas
2007	Earthquake in region. Massive tides break over coastal bar for first time—equinox peak risks. About 300 houses damaged. Innumerable fishing boats (>250). Traditional African religious ceremonies in heavy demand to deal with "crises". Saltmarsh farm land failing. Livestock grazing minimal—istorical ranching impossible
2008	Fishing income bad. "No place for fish". Beer trading helps. Door-to-door womens' fish trade in Maputo cut by development/refurbishment with gated community and security guards. Traders going out of business—dependence on markets. Public transport prices attacked/reversed. "Out of control" food and fuel riots in Maputo include Bairro. Water pipelines reach Bairro. Water-needy "Green Revolution" (biofuel sugar) in Mozambique. Dam projects (illegal) commercial deforestation. Large smelter operating upstream of Maputo Bay. River/bay pollution. Negative 'S. African' youth attitudes
Date	Msamgamkuu: next to conservation and development area at Mtwara in southern Tanzania
1818	Village founded by Mozambiquan migrant
1930	10 houses on beachfront, few boats. Population small, stable

Table 8 continued

Date	Msamgamkuu: next to conservation and development area at Mtwara in southern Tanzania
1940	Village expanding—est 30–40 people. Fishing good. Distant fishing also underway
1952	Floods in area. Cassava and other traditional crops plentiful
1960	Colonial era ending. Population boost from nearby Mtwara development. Estimated 80 houses
1961	Democracy leads to "selfishness", fewer barriers to cross-border fishing and trade (family ties)
1966	Strong storm
1967	State agriculture reforms: resettlement/hardship, market uncertainty. Migrants arriving from Mtwara
1970s	Population rising with parental age falling. Outsiders/migrants undermine traditions. Invasive starfish harms reef. Rising pesticide use (cashew). Coconut expansion, deforestation (natural cover). Cassava surpluses declining
1978	Severe floods, storms stronger, seawater more turbid, fishing decline sets in
1980	Population up—estimated houses. Farm yields/prices down. Deforestation accelerating. Fishing migrations and farming distances increase. Goat numbers rising. Millet farms failing
1982	Ferry boat link to main markets (Mtwara and beyond) capsizes
1985	Rains becoming poorer—distance to wells rising
1988	Cassava disease
1990	Soil "tired". Bush fires/slash-burn more common. Fisher numbers rising, with longer distance migrations
1995	Rice farms suffering (drought). Human diseases up (malaria, HIV, skin)
1997	Outsider fishers (local and foreign) catching more fish in near offshore areas
1998	Fish decline (temperature), dynamite ban. Floods, onset of drought trend. Village crops failing—rising use of distant farming camps subject to credit and crime. Switch to drought resistant crops
2000	Perceived sea changes affecting fishing: wind (unpredictable/strong), current, turbidity, depth. Mtwara development corridor impinges on farmland, communities resettled in Msamgamkuu
2001	Marine and land protected area gazetted on village edge—loses fishing access. Declining fish prices (traders)
2003	Monkey prevalence (eat crops) and pest problems rising—crop damage/theft affects millet, maize, groundnuts
2004	Mtwara fish prices low versus intererior. Longer distances to market. Tsunami—lingering water turbidity hits ambulant fishing (octopus/shells). Diving (masks) necessary. Vegetable oil price hikes hit homes, businesses
2005	Fish decline quickening but market still weak. Crow of Thorns starfish invasion of reef. Rising reliance on mangrove from Rovuma river estuary. Seining using SCUBA drive-fishermen offshore
2007	Govt pesticide changes—shortages. Cashew yields suffer. Fishing enforcement hits incomes. Roaming goats (shift to faster cycle livestock)/monkeys wreck crops. Villagers losing respect for others/property
2008	Population shift as Mtwara port expands (relocations to Msamgamkuu). Younger popn. of 5000+. 100 boats. Incomes falling: few livelihoods, farmers fishing more to buy food. Cashews sick/abandoned
Date	Msimbati: large village (Mtwara district) in a rural conservation/gas project area in southern Tanzania
1940	Fish, trees plentiful. Crops largely subsistence. Shark fishing. Few people/houses (200). Families live together
1958	Village expanding in colonial era (natural increase). Cashew/cassava cash crop expanding. Groundnut failure

Table 8 continued

Date	Msimbati: large village (Mtwara district) in a rural conservation/gas project area in southern Tanzania
1961	Independence. Security issues (Mozambique war e.g. mines). Govt policies: make life "hard"
1966	Dynamite fishing starts? Destruction of coral reef proceeds
1972	Govt promotes coconut crops along coast. Old people getting poorer—young have "all the money"
1973	Popn rising. Govt Ujaama "farm until you die" policy—settlements to coastal areas. Govt promotes fishing (small mesh nets). Investments in bigger boats. Fish prices rising—markets extending
1974	Deforestation (inc colonial reserves) for cash crops (coconut/cashew) accelerating. Subsistence crops failing (drought).
1982	Gas exploration near Msimbati leads to temporary jobs but subsequent employment is for outsiders
1983	Population/fishers rising fast. Dynamiting/poison fishing. Cross-border trade migrations (subject to Mozambique war). Larger families (youth "attitudes") affect income stability
1988/1989	Long-term drought starting? Crops failing, more fishing—with use of night-fishing lanterns to extending fishing hours
1990	School drop-outs, rising youth pregnancy
1993	Annual rains still decreasing. Soil "tired"—switch crops to more tolerant crops to compensate. Fish declining
1994	Malaria/HIV rising. Dynamite/poison fishing continue
1995	Cost of living rising—popn (4,000), land pressure/clearance (slash/burn). Govt crop prices falling. Crops failing due to heat. Drinking water scarcer. First beach hotel built nearby. MPA talks open with local villages (inland and coastal)
1998	Fishery decline notable (El Nino). Coral recovery after dynamite ban? Women's sea cucumber income down due to depletion, fishing, water depths. Dynamite fishing ban
1999	Water scarcity limits cashews/cash crops. Farming distances up (Rovuma river). Intestinal illnesses rising
2000	Sea cucumber earnings slide (ban enforced). Less farmland. Pests (ants) year-round
2001	Village agrees MPA, loses habitual fishing access. Nearby villagers tear-gassed for breaking rules. Fishing harder for women (physically/trading). Gas project wealth uneven. Cross-border trade by-passing Msimbati
2003	Popn rise + family division add to land pressure/subdivision. Few jobs, youths depend more on parents
2004	Tsunami damage. About 11 killed in wider Tanzania. Sea waves/tides/current unpredictable. Drinking water scarcer. MPA land use/lease limits
2005	Gas production, no electrification. Millet failing (heat). Less fish. Food prices up. HIV/malaria
2007	Nearest Ruvuma river ferry boat to Mozambique unusable. Cashews suffer from falling maintenance/credit/inputs
2008	Popn 12,000, 90+ dhows and canoes. Fishing distances up. Anger over limited MPA benefits and area use restrictions

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