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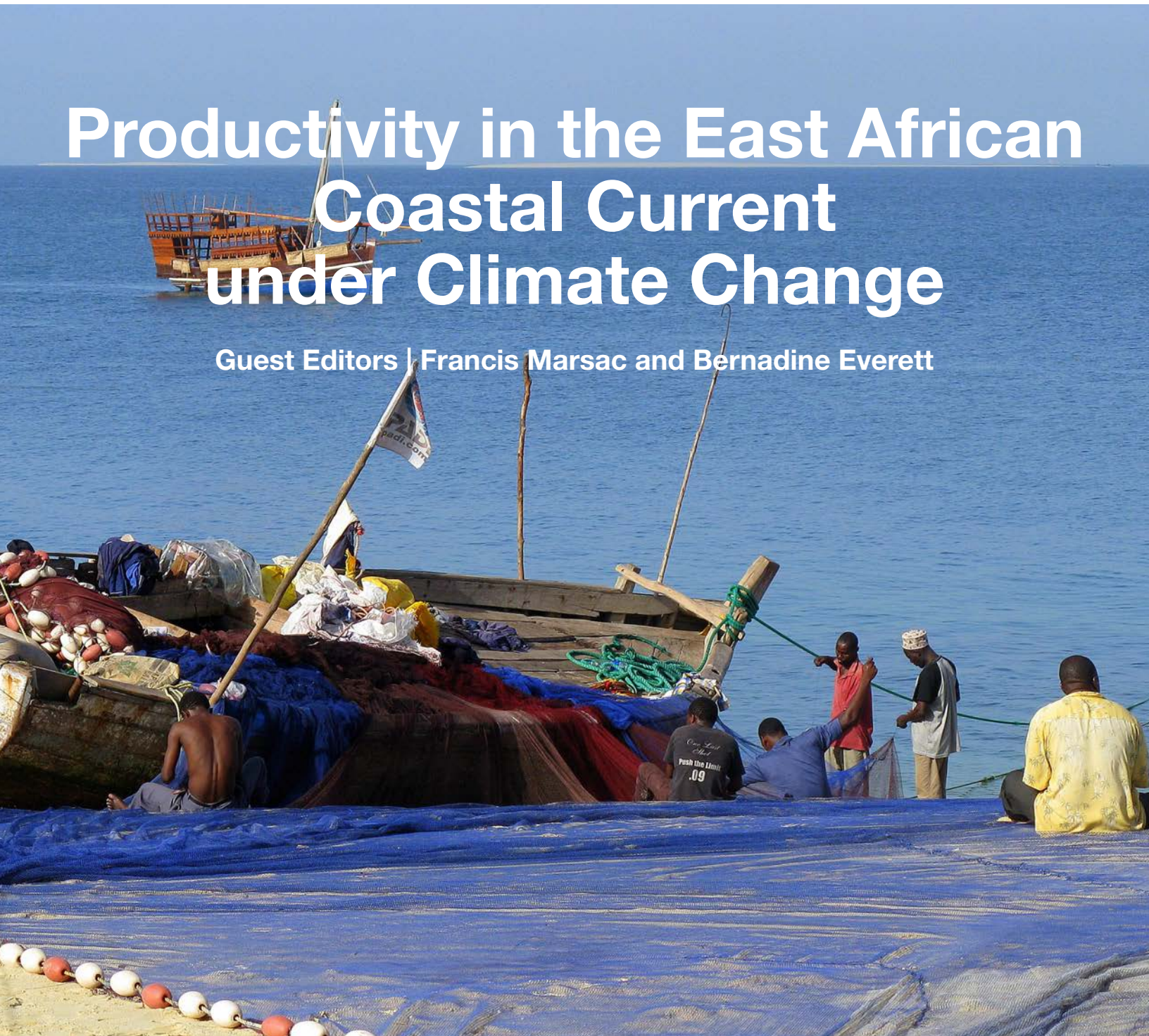
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Productivity in the East African Coastal Current under Climate Change

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Adaptive capacity of small pelagic fishing communities in coastal Tanga (Tanzania) to changes in climate-related phenomena

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Abstract

Studies examining the vulnerability, resilience and adaptation options of fisheries-dependent coastal communities have noted a decrease in viable options to respond effectively to the impacts of climate change. The extent of vulnerability is experienced in terms of varying capacity to respond to ecological changes through resource use practices. We analyzed the experiences of three coastal communities dependent on small pelagic fisheries in Tanga region, Tanzania, and their responses to the changing availability of fisheries resources. The study illustrates how conditions associated with upwelling, while not readily obvious to fishers, match some of their fishing strategies, with implications for fisheries-dependent livelihoods. Yet, the fishers' perceptions are key determinants of the response options they adopt. Limited access to scientific knowledge also constrains the effectiveness of their response options. Our findings have important implications for the manner in which local and scientific knowledge systems can be integrated, particularly with regards to enhancing the adaptive capacities of coastal fishing communities through knowledge sharing.

Keywords: Sources of livelihood, Perceptions, Adaptive capacity, Small pelagic fishes, Climate change

Introduction

One of the most significant factors associated with the vulnerabilities of coastal fisheries-dependent communities to ecological changes effected by climate change, is their inadequate adaptive capacity (Cinner *et al.*, 2012; Islam *et al.*, 2014; Koya *et al.*, 2017). This is due to their inability to effectively reconcile livelihood practices with current patterns of ecological changes (Daw *et al.*, 2009). Climate change, and the conditions associated to upwelling have been found to have multiple biophysical and social ramifications on coastal fisheries, with consequent implications on food security and employment (Lam *et al.*, 2012; Miller, 2014).

Upwelling along the coast of Tanzania occurs during the northeast monsoon (Valera *et al.*, 2015). During

that period, the prevailing surface winds consistently blow from the north and with the effect of the Coriolis force, the surface water along the coast is pushed offshore. The water beneath, which is relatively rich in nutrients, then comes to the surface to replace the volume of water that has been moved offshore, and these waters accelerate productivity. Thus, coastal upwelling is often associated with increased productivity of both primary producers and small pelagic fishes. Conversely, during the southeast monsoon which occurs from April to October, the winds blow from the south and push the surface water from offshore towards the coast. This surface water, which is brought to the coast from offshore is poor in nutrients, and upon reaching the coast, pushes the rich bottom water offshore, thus decreasing the productivity

of both primary producers and small pelagics. The objective of this study was to examine the knowledge, understanding, experiences and responses of fishers and fishing communities to these conditions associated with upwelling and the implications to their livelihood endeavours.

The likelihood that the seasonal changes in productivity in the small pelagic fisheries resources may have had some implications on the livelihoods of coastal communities is high, but not well established. For example, changes in the distribution and abundance of small pelagic fishes have been noted as a possible outcome of the effects of weather variability on the ocean (Faleiro *et al.*, 2016). These changes may be species specific (Klutse and Nunoo, 2016). In contexts where the small pelagic fishery is an important aspect of community livelihoods, the impact of these changes will indeed affect these communities and expose them to livelihood vulnerabilities (Anderson and Samoilys, 2016). Such vulnerabilities are magnified by over-reliance on the fisheries, increasing pressure on the fisheries, but spreading the risks even further (Daw *et al.*, 2009). Limited options in limited environments ultimately disrupt the sustainable availability of fishes, household protein supply and distribution of revenue from the fisheries sector (Lam, *et al.*, 2012). The social aspects of vulnerabilities to climate change and upwelling in this regard can further be captured in terms of the varying levels of risk that different population groups within the fisheries-dependent communities become exposed to, owing to their different social status in terms of gender, age, main occupation and ability to draw on other resources (Islam, *et al.*, 2014; Burton and Cutter, 2008).

Effective adaptive capacity in this regard can be influenced by several factors. Sometimes, it is the result of how population groups firstly perceive the causes of their risk, and are then able to take advantage of existing and emerging opportunities in response to the resulting biophysical and social disruptions affecting their sources of livelihood. These responses are noted to be in the form of various behavioural, social, organizational and technological mechanisms (Adger, 2006; Cinner *et al.*, 2012; Adewale, 2014). People's perceptions on the factors leading to changes in the fisheries, and hence their vulnerability, is thus a crucial determinant on the adaptation choices that they make (Katikiro, 2014). There is however, inadequate appreciation on the relationship between perceptions of risk to the adaptive choices taken by fisheries-dependent

communities, such as those within small pelagic fisheries, and their response to upwelling conditions (Anderson and Andrew, 2016).

Some studies adopt the asset-based livelihood approach and delineate the varying inadequacies in requisite assets as contributing to vulnerability (Cinner *et al.*, 2009; Islam *et al.*, 2014). While such understanding is critical for examining adaptive capacities of fisheries-dependent communities, coastal people's tradition of '*reading the sea*' and their ageless engagement with it for livelihoods and culture, and a knowledge which has equipped them with adequate experience on the conditions of their natural environment, has facilitated taking advantage of biological productivity such as those induced by upwelling conditions in particular (Tobisson *et al.*, 1998; Nirmale *et al.*, 2007). This knowledge is however sometimes taken for granted, and is increasingly becoming more complex in the context of climatic changes (Shyam *et al.*, 2015). Increasing irregularity of weather patterns is making predictions difficult, diminishing the effectiveness of traditional responses to livelihood engagements. Cheung (2015) has asserted that it is even more difficult for people to relate traditional livelihood patterns to the changing conditions associated with upwelling. Understanding local perceptions on such complexities and how people adapt is thus an important contribution to knowledge (Perry and Sumaila, 2007).

The vulnerabilities that coastal fisheries-dependent communities face may also be aggravated by institutional ineffectiveness, particularly fisheries management systems which are meant to support artisanal and small-scale fisheries in dealing with changing sea conditions. Inadequate and untimely information systems on weather changes, or poor sharing of scientific information on upwelling locations (Shirley *et al.*, 2012) are examples. Fishers also harbour discontent with these institutions, seeing most as geared towards revenue collection and uninterested in supporting them in the context of climate change. The fisheries thus continue to be exploited in more or less traditional patterns with varying levels of success.

Inadequate comprehension of the intensity or magnitude of the threat arising from changing sea conditions may also influence the nature of adaptation responses (Forster *et al.*, 2013), and fishers are likely to persist within the confines of their traditional livelihood systems, weaving themselves into prevailing

uncertainties. Oliver-Smith (2009) notes the prevailing uncertainty in such situations is “both at the level of physical impacts and at the level of responses to adaptations in human communities”. This uncertainty has sometimes been the basis for extended exposure to vulnerable situations with long term consequences. Uncertainty can be generated by conflicting messages between perceptions on change and experience of change, especially where people cannot clearly give witness to physical changes in the marine environment. Such issues are not well captured in studies on the social implications of climate change-related conditions on coastal fisheries-dependent communities.

At the same time, it is also difficult to delineate how people and their complex relationships with local fisheries systems may respond to change. Social dynamism, new ideas and new experiences may open up varying adaptation possibilities for certain population groups within the same fisheries, albeit short-lived. Yet, studies on adaptive capacity have not often captured these possibilities and their implications in both their positive and negative dimensions. Likewise, plausible options such as re-organization of the corresponding fisheries value chain as adaptation from risk are not well articulated, giving indications of a gap in knowledge.

The objective of this study was to examine factors influencing the adaptive capacity of three fisheries-dependent communities in coastal Tanzania, associated with their perceptions and experiences of the effects of upwelling conditions on the local small pelagic fishery. The study analyses community livelihoods by interrogating how these communities (i) perceive and relate the causes of changes in the availability of small pelagic fishes to upwelling related conditions, (ii) the implications such perceptions have on their livelihood choices, and (iii) their perceptions of the choices they make to adapt to these changes.

Materials and methods

The study area

This study was conducted between April and December 2017 in coastal fishing communities around three landing sites in Tanga region, north-eastern Tanzania (Fig. 1). These were Kasera (Sahare, Tanga Municipality), Vyeru (Monga-Vyeru village, Mkinga District) and Petukiza (Zingibari village, Mkinga District). These sites were selected due to predominant use in the small pelagic fisheries in the region, which since 2010 has become increasingly important in the small pelagic fish trade.

Kasera landing site along the Sahare coast (see Fig. 1), is an urban location within Tanga Municipality. Municipal authorities estimated that about 70% of Tanga municipal residents depend on Kasera landing site for fish consumption and trade (pers. comm.). Kasera is also the main market for small pelagic fish in Tanga. The Sahare fishing grounds are under the jurisdiction of the Tanga Coelacanth Marine Park, which provides an added management intervention for the local fisheries. The other two sites, Vyeru and Petukiza, are rural sites in Mkinga District, located in the north of Tanga Municipality, about 20 and 40 km by road respectively from Tanga City along the Tanga-Horohoro highway. Data on the number of fishers and vessels at the landing from 2017 showed that Kasera had 1,501 fishers and 171 craft, and Vyeru had 750 fishers and 50 craft. Estimates for Kasera and Vyeru were drawn from a rough figure of 15-45 fishers per boat (in good seasons Mashua carry up to 45 fishers per fishing trip). Estimates for Petukiza of 2,118 fishers and 311 craft refer to 2016.

Data collection and analysis

A combination of qualitative and quantitative techniques was used to examine the livelihood impacts and adaptive capacities of these communities in response to upwelling related conditions. A structured questionnaire was used to collect comprehensive data to map the pattern of livelihood activities in the fisheries, vulnerabilities and adaptation strategies. Eighty-eight fishers were purposively selected from the landing site registers at Kasera and Vyeru, and fishers from Petukiza were selected by the local Beach Management Unit (BMU). The selection targeted both skippers (*nahodha*) and crew members in order to capture different experiences with the sea. Observations were also conducted to visualize the pattern of community engagements with the fisheries. In addition, in each community, Focus Group Discussions (FGDs) and In-depth Interviews (IDI) with women, long-time and retired fishers were conducted, including discussions with other stakeholders with fisheries management responsibilities. The discussions examined their interpretations of the nature of social dynamics influenced by changing fisheries and the implications to adaptive capacity.

To investigate how fishers communicated about ocean upwelling, diagrams of the process and ensuing sea conditions were used as visual guides to generate discussions. Visual guides were used because upwelling has no known terminology in the local language (Swahili)

used by the fishers. Community vulnerabilities were assessed in relation to the following indicators: (i) experience and perceptions of factors leading to changing fisheries in the long and short term; (ii) implications of livelihood dependence on small pelagic fisheries; and (iii) adaptive capacity to these changes.

fish from the boats (porters), fish processing, boiling and drying particularly sardines (*dagaa*), and retailing cooked food (mama lishe). Small-scale farming is practiced by both men and women. Full time farmers are mostly elderly (30%), retired from fishing and related employment, while other community mem-

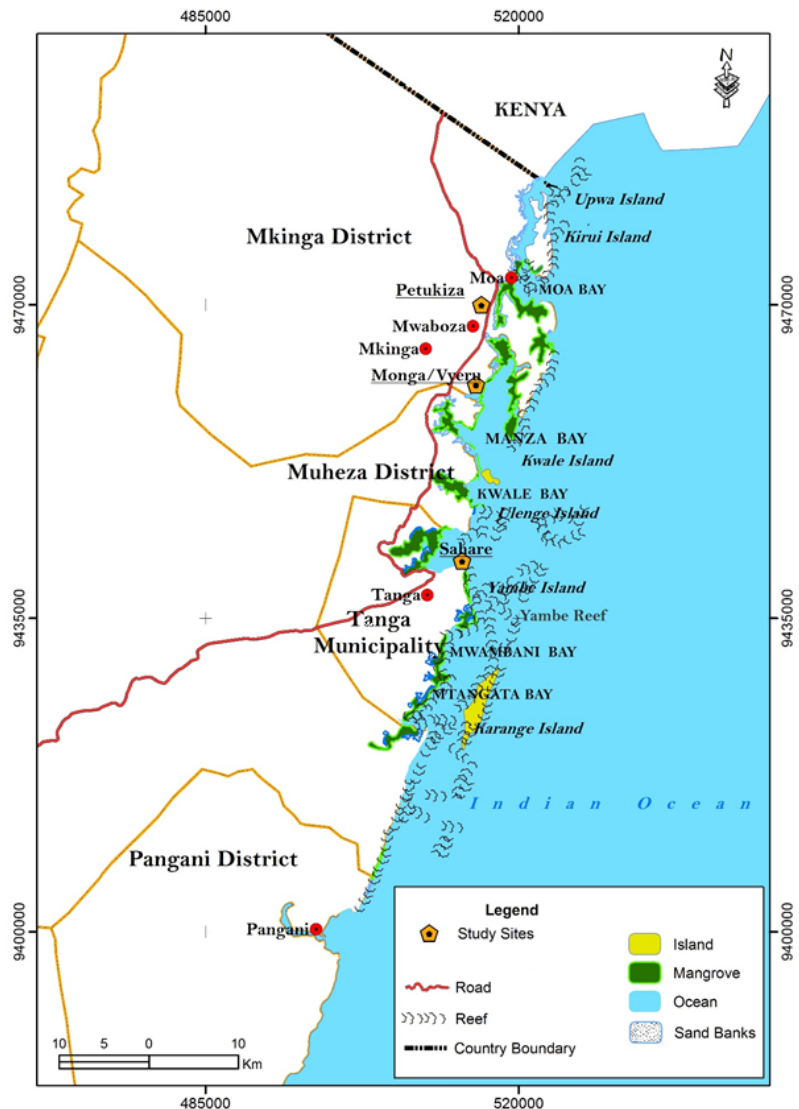


Figure 1. Map of Tanga Region, north east Tanzania, showing the study sites of Sahare, Vyeru and Petukiza (Source: Julitha Ipopo, IRA-UDSM, December, 2017).

Results

Community characteristics

In all communities, about 90% of the men were found to be engaged almost entirely in fishing and fish-related businesses. Men around Kasera enjoyed several other options, given its urban location and access to more employment or business opportunities. Women engaged in what are perceived as petty trades such as fish mongering, off-loading of

fish from the boats (porters), fish processing, boiling and drying particularly sardines (*dagaa*), and retailing cooked food (mama lishe). Small-scale farming is practiced by both men and women. Full time farmers are mostly elderly (30%), retired from fishing and related employment, while other community mem-

bers would engage periodically in farming during off-fishing seasons. During the study it was established that most of the fishers had basic literacy skills, 50% had completed primary school education, and 11% of them had completed secondary education. Only 8% had not received any formal education, and 13% did not complete primary education. The fishers however explained that

they do not only undergo classroom-based education. They also go through informal apprenticeship, such as in fishing net mending and sea experience through fishing. Hence, the ability to read and write was not the primary means through which they were enabled to cope with the sea.

Knowledge about the sea and fishing was shared among the fishers through word of mouth or by cell-phones, and this system was important and effective in preparing them for their encounter with the sea. Fishers were of different ages and from different places of domicile. About 20% of the fishers mentioned that they have relocated from other locations to Tanga, especially from the islands of Pemba and Unguja in Zanzibar, and the rest were local to the fishing villages. Together, they had encountered a wide variety of experiences of the sea. Seasonal or local migrant fishers, mostly from the two islands, visited Tanga especially during the February-April and August-November fishing seasons. They set up camps (*dago*) near the shore according to a customary arrangement of accommodating migrant fishers in respective fishing villages. The timing of these visits was estimated to coincide with the end of each rainy period. Long-term experience in fishing among seasoned or migrant fishers was most relevant to the fishers' ability to 'read the sea', and this experience was evoked when discussing upwelling, climate change and small pelagic fisheries.

Upwelling conditions and the fisheries

In order to determine the links between upwelling-related conditions, the prevalence of small pelagic fishes, and hence people's livelihoods, the study examined fishers' conceptualization of upwelling as a phenomenon. It was observed that the conditions

associated with upwelling were communicated from two different positions; as an actual experience, and to upwelling as a perception of a certain phenomenon. Old-time fishers, as well as including divers who had been beneath the surface, were able to account confidently about changing sea temperature conditions. Other fishers gave accounts of changes in wave strength that they perceived influenced changes in sea water conditions - changes which they understood to have implications for productivity in the fisheries. Two conditions indicating such changes were mentioned: (i) changes in sea water conditions; and (ii) changes in the availability of small pelagic fish.

Changes in sea water conditions

Changes in sea water conditions were categorized as changes in sea water temperature, and changes in the quality of sea water. Each change was seen to be a function of the changes in the weather seasons, and associated changes in temperature, strength or direction of the winds, and rainfall patterns. These sea conditions or phenomenon were named in a variety of ways (Table 1).

(i) Sea water temperature

Fishers also mentioned that they had experienced changes in water temperature with a general increase in temperature over the last few decades. Referring to the techniques or catching small pelagics, whereby a diver usually goes under the surface to set fishing nets, a long-term fishing skipper from the islands who is also a diver said, "during the past, it was very cold in the sea when one goes out fishing, especially at night". Fishers used to use heavy clothing during fishing trips to keep warm.

Fishers who are also divers explained that during the NE monsoons they experienced different levels of

Table 1. Fishers' local terms for changes in sea water conditions.

Local term/reference of condition	Frequency	Percent
Rainwater run off (<i>Mumbu</i>)	35	39.8
No specific name	27	30.7
Cold temperature	8	9.1
Changes in the water quality	8	9.1
Curling water (<i>tububwe/dunguliani/mboji</i>)	6	6.4
Spring tide (<i>bamvua</i>)	3	3.4
High sea surface temperature	1	1.1
Total	88	100

sea temperature. A fisher explained that sometimes, the deeper one went, the colder it became from the warmer surface level water, giving an impression of the sea having different layers. Another diver-fisher further explained that during the NE monsoons, they may experience the water column as stratified into two or three layers of temperature. The number of layers can change from one year to another.

Adding to this, another fisher claimed that “nowadays, the sea is relatively warmer and the type of coldness that existed at night in the past is not felt anymore. Generally, fishers felt that the sea is becoming warmer for longer periods, and that, not only has the sea become warmer in the recent past, but they claimed that the air above the sea has warmed as well.

(ii) Quality of sea water

Fishers explained that the NE monsoons bring heavy rains which cause runoff from inland which also carry sediment and debris that pollute the water, locally known as *mumbu*. During the NE monsoon, water becomes “dusty”, scouring debris, sand, broken corals, seagrass and all other bottom materials and thus the season “cleans” the ocean. *Mumbu* is regarded as unproductive for a certain period because it disturbs the quality of the water. However, this disturbance was considered as temporary, because fishers claimed that after a short period, the sea becomes quite productive. Scientifically, runoff from inland bring terrestrial nutrients to the coast by rivers which settle on the bottom. These can then be brought to the surface by upwelling and hence increase surface productivity. The aftermath of heavy rains is mostly favoured for fishing because of the understanding that the disturbance of the water brings nutrients up to the surface which attract fish leading to abundant catches. Fishers in Vyeru, for example, recalled how they experienced heavy rains for a whole day in May 2016. But “*after one week, we were able to harvest bangra at its boom at our local fishing grounds*” (FGD with fishers, Vyeru, 29/10/2017).

During the SE monsoon, the fishers mentioned that the sea was said to be a bluish colour and the inshore waters become very clear, which was relatively unproductive as compared to the disturbed water accompanying the NE monsoons.

Causes of changing sea water conditions

Fishers’ perceived that changing sea water conditions were a result of weather changes influenced by the monsoon winds, including the changing patterns of wind strength.

(i) Weather conditions

Weather related factors were explained in terms of changing patterns of wind strength and temperature. Such experiences were acknowledged as climate change (*mabadiliko ya tabia nchi*). Climate change was expressed in terms of unpredictable changes in rainfall patterns (24%) and changes in wind strength (21.5%). About 24% of the fisher respondents also mentioned that other changes that signified climate change included changes in the timing of spring tidal cycles (*bamvua*) and in the monsoon seasons and their accompanying conditions. For example, very heavy rains for short periods were said to cause a drastic disturbance in fishing patterns, inhibiting access to fishing grounds because of safety and impaired visibility, and also disturbing the marine environment.

(ii) Timing of wind strength

Generally, wind strengths were said to not have changed much, but people’s predictions on the timing and strength of the winds was increasingly unreliable. Nevertheless, according to the fishers, stronger winds were still experienced during the SE monsoons than in the NE monsoons. Moreover, wind strength was associated with disturbances in the sea and ultimately to sea water conditions. Although wind force was said to be stronger during the SE monsoon, fishers believed that wave action did not penetrate down to the bottom and only affected the surface with no impact on fishing.

(iii) Strength of sea waves

Fishers also explained that during the NE monsoon “powerful waves” penetrated the entire water column, from the surface to the bottom, and fishing became difficult. According to fishers, this was the period of “turbulence”. In contrast, during the SE monsoon, wave action was only felt at the surface – the force of waves did not reach the bottom. However, it was said that some inshore debris on the bottom was taken offshore by the “current” at this time.

The small pelagic fisheries in Tanga

Uono ndio habari ya mjini! (lit: *uono* is the talk of the town). This was a common saying in the study site localities and was used to signify the importance of this small pelagic fish species and its association to community livelihoods and the local economy. *Uono* (Eng: Commerson’s anchovy, species: *Stolephorus commersonii*) was used as a generic term to refer to all small pelagics of the family Engraulidae found in the area. According to Breuil and Bodiguel (2015), the

Table 2. Average range in landings per fishing trip of the most common fish species (NE monsoon, 2017).

Species (Local name)	English name	Minimum weight (kg)	Maximum weight (kg)
Bangra	Indian mackerel	1	120
Kibua	Indian mackerel	3	700
Dagaa damu	Spotted sardinella	1	50
Uono/Dagaa mchele	Commerson's anchovy	14	2500
Gololi	Big eye scad	1	30
Msumari	Shortfin scad	12	100
Dagaa simu	Indian scad	15	100
Bilibili	n.k	4	35
Dagaa upapa	Rainbow sardine	5	50
Ngarengare	Banded needle fish	30	300

Source: Fishers, Field data- PEACC study 2018.

family consists of eight other species, namely *Engraulis japonicus*, *Stolephorus heterolobus*, *S. punctifer*, *S. indicus*, *S. devisi*, *Thryssa baelama*, *T. setirostris* and *T. vitrirostris*. The importance of *uono* is, however, a recent phenomenon in this area. In this paper, the term *uono* is used to refer to all species of the family Engraulidae found in the fisheries of Tanga.

According to oral histories, *uono* fishing used to be an insignificant component of the local fishery, particularly in the fisheries value chain. The fishers, who basically operate a multi-species fishery system, mentioned that some years back, large pelagic and demersal fish species were preferred because of their higher monetary value and abundance. They also recalled that about 70% of the local small pelagic landings were purchased by Interchick Company, a chicken production and marketing company based in Dar es Salaam, which was then the major buyer of dry sardines and anchovies for production of chicken feed in the country. The prominence of *uono* was a phenomenon of the past 10 years. In 2007, it was said, only two villages, Mwaboza and Jasini, were known for *uono* fishing along the Mkinga coastal area. Five years later, by 2012, two other villages, namely Zingibari and Monga-Vyeru, were engaged in *uono* fishing and experienced high catches. By 2017, almost every landing site in Tanga was engaged in the *uono* fisheries and associated business.

Main species caught and average landings

The five small pelagic fish species caught most commonly along the coast of Tanga that were mentioned were Indian mackerel, *bangra* (30%), banded needle

fish, *ngarengare* (23%), Commerson's anchovy, *uono* or *dagaa mchele* (34%), and *ziha* (13%). In terms of fish landings, most fishers mentioned that *uono/dagaa mchele* was the most prevalent, followed by other species with varying catches including *bangra*, *kibua* and *dagaa damu* (Table 2).

As illustrated above in Table 2 above, *uono* was caught in higher quantities than other species.

Main fishing gear:

By 2017, the main fishing gear was the ring net. This net, as noted by fishers, represented a complete change in fishing gear over the last 5 years (Fig. 2). The prominence in ring-net fishing within the Tanga fisheries was also noted by Anderson and Samoilys (2016), indicating an increase in the number of ring-nets over time from 46 to 180 in Mkinga District and from 36 to 50 in Tanga District between 2007 and 2013.

The main fishing craft used in the *uono* fishery was the *mashua* (large boat, about 12m long) or *ngwanda* (small boat, about 8m). On average, 87% of the fishers mentioned that they use the *mashua* which had a crew carrying capacity ranging from 15 to 45 persons per fishing trip. The *mashua* is normally accompanied by a number of smaller support crafts (locally called *dau* or *plaud*) on fishing trips, which carry lanterns or hurricane lamps required for illumination to attract the fish, and which surround fishing locations where the nets are cast. *Ngwanda* are also often used to carry the load of fish. The use of other smaller craft for fishing such as *mtumbwi* was found to be minimal, and are mainly used

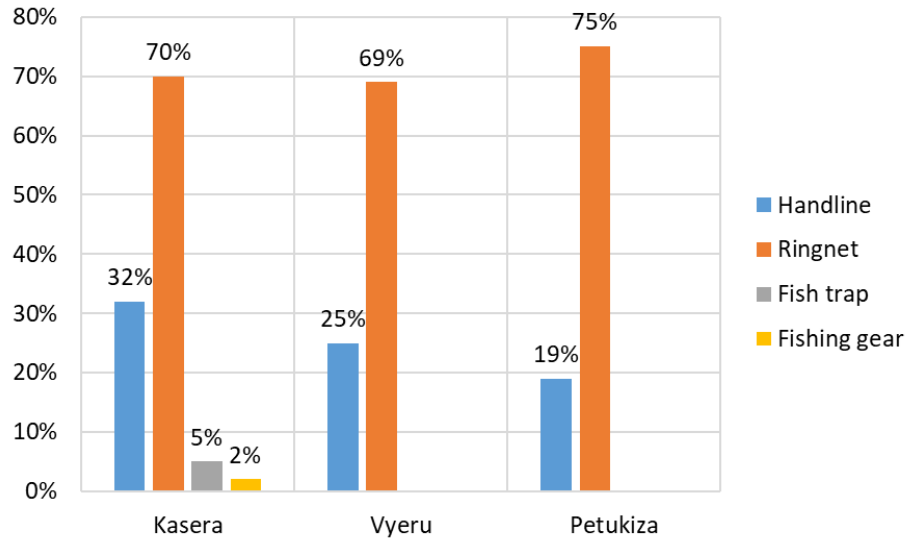


Figure 2. Main fishing gear by area used in small pelagic fisheries in Tanga region, north eastern Tanzania (June 2017).

by stake and trap fishers targeting reef fishes. These vessels usually engaged two or three fishers per trip, and were not ideal for *uono* fishing because of their inability for large haulage. Larger fishing crafts were most preferred, but were unaffordable for many fishers.

Perceptions on quality of fishing grounds

Fishers maintained a more or less steady relationship to common fishing grounds. They claimed that there have not been any significant changes in the preferred fishing grounds over the last 5 to 10 years. The seasonally determined patterns of fishing at certain locations in particular weather were largely similar to what had been practiced for the last 10 years. This meant that since the 1990s, fishers have been using the same fishing grounds. Frequently visited fishing grounds in the last 5 years have been around the reefs of Chundo, Wamba, Nyuli, and Jambe (see Fig. 1). Other grounds

used less frequently were Mwamba nyama and Boma reefs. Seasonal migration to distant fishing grounds during certain periods was also common, as fishers synchronise their activities with fishing seasons.

Fishers from Vyeru and Petukiza mostly exploited Chundo and Wamba reefs. Vyeru fishers, who are located geographically closer to the reefs, also preferred these fishing grounds because of proximity. Kasera fishers were able to exploit a wider range of fishing grounds (Table 3). The farthest distance that fishers travelled to fishing grounds was 6 km, while the closest was 0.5 km.

Trends in small pelagic fish catches

Fishers in this study explained that they had been increasingly experiencing changes in the availability of small pelagic fish in the recent past (Fig. 3). About

Table 3. Distance covered by fishers to fishing grounds per landing site.

Distance in Kilometers	Landing sites		
	Kasera	Vyeru	Petukiza
0.5		6%	
1	2%		
2	17%	13%	20%
2.5	6%		
3	32%	50%	53%
4	32%	25%	20%
5	7%	6%	7%
6	6%		
Total	100.00%	100.00%	100.00%

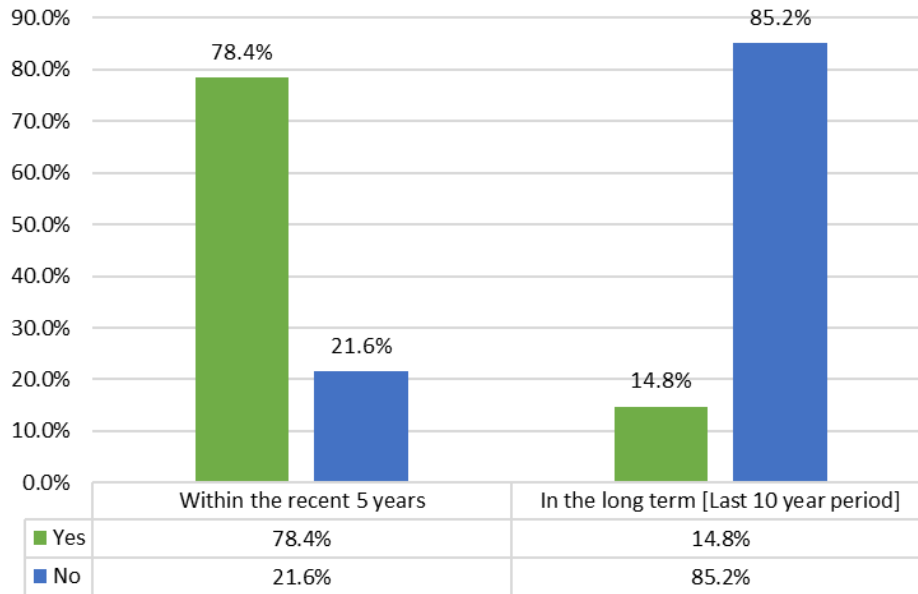


Figure 3. Fishers experience of changes in small pelagic fish catches over the long and short term in Tanga (May 2017).

78% of the fishers noted that they had witnessed significant changes in fish catches in the last 5 years (i.e. since 2012) compared to only 15% who had experienced changes in the last 10 years.

Of those who indicated that they have experienced changes in the last 5 years, 32% of the respondents mentioned that there was a sharp decline in fish catches, while 39% indicated that there was a slight decline, and 18% maintained that they had not seen any changes in catches. About 8% of these respondents mentioned that they were catching new species of fish in the last five years, that was explained as obtaining small catches of different species at different times. Obtaining the same species of fish in one major haul was not as common as it used to be in the past.

Perceived factors causing changes in availability of small pelagic fish

Among the key factors perceived to be responsible for variable fish catches included (i) fishing practices and (ii) weather related factors.

Past fishing practices

Changes to the small pelagic fishery in Tanga was perceived as being directly related to past and present fishing practices, including destructive fishing. These practices were (i) the use of destructive fishing methods that led to a decline in reef and demersal fisheries, (ii) introduction of small-scale purse seines (ring nets), and (iii) expansion of the *uono* market due

to increased demand. Firstly, fishers perceived that the *uono* fishery was the inevitable response to the destruction of the neighbouring coral reef ecosystem around Tanga through the use of dynamite. In 2008, Samoilys and Kanyange (2008) note that dynamite fishing in the area had resulted into significant loss of biodiversity and fisheries productivity. The high catches realized with the use of dynamite proved a deterrent to any effort to curb this practice. During this study, it was however claimed that dynamite fishing was no longer a major threat to these fisheries. The beach seine was also used in the past, viewed as a necessary alternative to the less effective traditional fishing methods (gillnets, fish traps and handlines), which had a low productivity potential (Samoilys and Kanyange, 2008).

As a measure to curb dynamite fishing and other forms of destructive fishing methods, the Marine and Coastal Environment Management Programme (MACEMP) working with the coastal area management initiative, Tanga Coastal Zone Management Programme (TCZMP), introduced ring nets as an alternative fishing gear. This initiative significantly changed fishing practices in the area in several ways. Firstly, these nets are species-selective and were ideal for small pelagics, hence fishers began to concentrate more on catching small pelagics (KII, Mkinga DFsO 28/6/2017). The Fisheries Development Division reported that estimated landings of small pelagic fishes in Tanga region increased from under 500

tonnes in 1988 to more than 2,000 by the year 2010 after the introduction of ring nets (Anderson and Samoily, 2016).

Secondly, this fishing practice demanded a significant amount of labour for managing and hauling the catch, and engaged more people as boat crew, albeit varying in numbers according to seasons. Thirdly, according to the fishers, the use of ring nets not only enabled them to catch small pelagics in plenty, but they also reduced the use of dynamite, since, as one fisher explained, '*uono haupigwi bomu, unautegea kwa taa, kama mchumba unamlewesha na mwanga- vitu vya kung'aa, nae anakuja tu*' (lit: *uono* is not caught by dynamite, you trap it with lanterns, it is coaxed as one woos a lady with shiny things, and she just comes willingly). This saying implied that destructive methods were not ideal for *uono* fishing, hence have allowed for fish populations to multiply.

At the same time, the market for *uono* expanded beyond Tanga and Dar es Salaam, as a result of inadequate supply of the much preferred *dagaa* from Lake Victoria to satisfy the increasing local and international markets (FGD with Skippers, Sahare landing site, 27 June 2017). Traders come from as far as Arusha and the Democratic Republic of Congo (DRC). This growing market spurred local production of *uono*, and indeed, the local economy. Experiences of the more recent past (from 2012) was however attributed to many other factors that caused negative impact on the fisheries as shown in Fig. 4.

Recent fishing behaviour

In all communities, it was claimed that the population of fishers was increasing significantly. This increase may have partly been influenced by changes in fishing methods that allowed the entry of more fishers. Although exact data on the number of fishers could not be established during this study because of lack of records, it was claimed that the open access nature of Tanzanian coastal fisheries permitted an unregulated influx of fishers to the local fishing grounds. The number of registered vessels per landing site was often topped up by seasonal migrant fishers who visited the fishing villages during peak fishing seasons. Some migrant fishers would set up temporary camps (*dago*) and their numbers were noted. But it was reported that many more would visit local fishing areas without officially declaring their entry to local authorities along the Tanga coast.

A related concern was daylight fishing with ring nets, which was said to be not only coercive, but was also claimed to be contrary to customary fishing norms. A local fisher explained, '*fishing uono during the day demanded 'seeking and chasing it wherever it has settled, and catching juveniles without restraint, and hence destructive'*' (MA, Sahare, 27/09/2017). The timing of fishing was thus a controversial issue especially between local fishers and the more resourced migrant fishers. Local fishers claimed that traditional fishing patterns for *uono* (which specified periods for daylight fishing to be conducted only during the months of June, July and August), and also respect of breeding seasons were

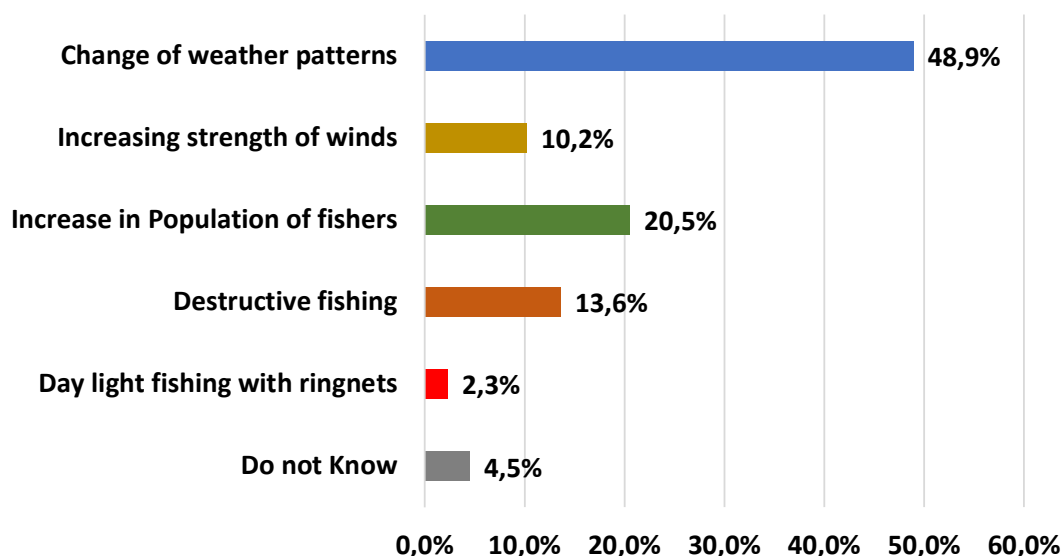


Figure 4. Perceptions on factors contributing to changes in small pelagic catches in Tanga region, Tanzania (May 2017).

being violated. Kasera landing site noted 10 fishing crafts which caught fish in daylight along the Sahare coast in inshore waters, and 20 others fishing further offshore (KII, Kasera Landing Site, Fisheries Officer). About 70 vessels were engaged in night-time fishing. Another fisher at Sahare complained, “*mavuvi ya uono sasa yamekuwa hayana matulizo, uko kila siku, si kusi wala kaskazi, una lazimishwa na wavuvi wa mchana*” (lit: *uono* fishing has now become a daily affair, and there is no resting nowadays, neither during the southerlies, nor during the northerlies, it is constantly forced by daylight fishers (AK, Sahare, 26/09/2017). The decline in *uono* fisheries in the recent past was thus attributed to lack of effective traditional restrictions.

Perceptions of upwelling and availability of small pelagic fish

The NE monsoon period was mentioned as particularly productive because of the availability of nutrients on the surface (Fig. 5).

However, despite recognising a relationship between upwelling conditions and the availability of small pelagic fish, fishers could not directly attest to these conditions as the primary source of productivity in the fisheries. Levels of productivity of the fisheries were understood as normal responses to the seasonal and weather changes. A total of 61.3% of the fishers indicated that they did not know that the phenomenon had any significance to the fisheries, while only 27% indicated that it had an impact on the fisheries. About 50% indicated that the normal seasonal weather

changes generated the desired functioning of the small pelagic fisheries, bringing about their abundance at certain times, but also a period where the fisheries were supposed to be left idle to allow rejuvenation. The inter-monsoonal seasons (locally known as *leleji/maleleji*) were mentioned to be the best fishing periods because of the calm weather conditions, and also the times that small pelagics become plenty. Of the two interchanging monsoons, that from the NE to SE resulted in more abundance of small pelagics than that from the SE to NE.

Conditions on the fishing grounds:

The perception of fishers of the significance of upwelling was also examined in relation to how they gauged the best fishing grounds. Fishers in all three landing sites mentioned that they have not changed fishing grounds for a long time. This was because these fishing grounds were still seen as reliable locations with respect to small pelagic fishes, and also, because of their continued ability to access these grounds irrespective of weather changes. Some of the reefs were favoured by the fishers because they were sheltered during bad weather. Knowledge of breeding patterns was another indicator that established how fishers related to the availability of small pelagics. About 59% mentioned that small pelagics breed around reefs and the pebbles around these reefs (kis: *kwenye miamba na changarawe*), and 22% stated that they breed along water currents (kis: *mkondo wa bahari*). In terms of breeding season, 45% of the fishers claimed that the best breeding season was during the NE monsoon, compared to

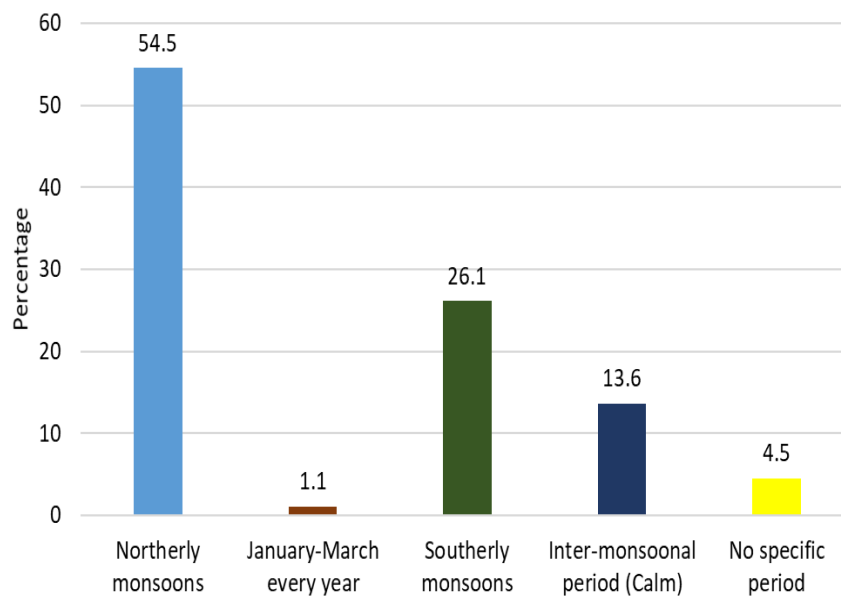


Figure 5. Distribution of small pelagic catches by seasons based on respondents.

28% who mentioned the SE monsoon. About 18% mentioned the inter-monsoonal period (kis: *maleleji*), and the rest did not know.

In addition, fishers maintained that small pelagics concentrate in the vicinity of the reefs and along water currents (*kwenye mikondo*) where it is believed that “*mchanganyiko wa maji unaleta samaki wengi zaidi*” (lit: mixing of water brings many fish). Mahongo and Shaghude (2014) mention that water currents along these reefs form part of the East African Coastal Current (EACC) system whose main core passes offshore on the eastern side of the Islands of Pemba and Zanzibar, but a smaller branch enters the Pemba Channel through the entrance separating the islands of Zanzibar and Pemba. The authors also noted that the EACC was relatively weak, but flows northwards throughout the year. Fishers were able to determine the location of these currents by their relatively higher water speeds compared to surrounding areas. During the NE monsoon, there is enhanced mixing with bottom water coming to the surface, leading to the surface water becoming “dusty” after scouring debris, sand, broken corals, seagrass and other bottom materials. According to the fishers, the NE monsoon “cleans” the ocean at the end of the season.

About 72% of the fishers however mentioned that over the recent past, there have been changes in the locations of water mixing ‘*mchanganyiko wa maji*’ (lit: mixing of waters), while 17% denied any such experience, and 11% did not know. Elaborating, 15% of them associated these changes with an increase in the strength of currents (kis: *kasi ya maji*), and the rest mentioned that there is a shift in their location. However, only 32% of the fishers target these new locations for fishing, and the rest have not changed their regular fishing grounds on the understanding that these new locations were not necessarily significant to fishing success.

Small-pelagic fisheries and local livelihoods

Changes in the availability of small pelagic fish had a significant impact on the welfare of fisheries-dependent communities in terms of (i) access to incomes and employment for women in an expanded value chain, (ii) simpler processing and handling of fish, and (iii) household protein consumption. These aspects were experienced differently with changing availability of small pelagic fishes. It was found that the value chain of the small pelagic fishery engaged many more actors than what had been experienced in the fishing of larger

fish species. Women in particular mentioned how the small pelagic fisheries allowed them to work in off-loading the catch as porters locally known as *Wabebaji*, in addition to the activities of gleaning, catching of small shrimp, fish processing and fish mongering. *Ubebaji*, which is currently a significant part of the small pelagic fisheries value chain in Tanga, has widened opportunities for income generation for many women after experiencing a decline in other sources of livelihood, including inland agriculture and was perceived as petty trades.

The marketing of *uono* was also simpler. The fish was sold to traders at landing sites, usually directly from the vessels after they docked. This system was different from how fish were marketed in other landing sites in Tanzania where the fish was auctioned at defined market places. In the case of *uono*, a small portion of fresh *uono* was usually sold to local consumers while the bulk was immediately processed through braising and drying for transporting to distant markets. Women respondents explained that this processing was relatively easier to handle than with larger reef fishes. One of them said, “you need a fridge or other means of preservation for large fish after harvesting, while *uono* simply needs braising and drying” (Fisher, Sahare, 4/7/2017). It was also established that post-harvest loss was minimal for small pelagics because of immediate processing.

Another important livelihood impact related to the small pelagic fisheries was the level of intake in household protein consumption. Although actual measurements of protein intake by households could not be established in this study, it was generally accepted that small pelagics, dry or fresh, were part of the diet in fishers’ and porters’ households almost daily, and was a common dish at the local restaurants (*migahawa*). Less advantaged households were those without members who provided active labour in the value chain, who had to buy or request for a handful of fish, hence the saying, “*increasingly in bad times, even a bowl of uono for relish cannot be offered to you*”!

Declining catches over the last few years have thus had various impacts in the communities. The biggest impact was in terms of declining incomes for individuals and for the general community, specifically experienced during the last 5 years (Table 4).

Declining catches also affected the level of transactions between sellers (fishers) and buyers (small and

Table 4. Felt impacts from sampled fishers in Tanga region of changes in catches over the short term (5 years, 2012-2017) by level and severity.

	Individual level impacts	Percentage	Community level impacts	Percentage
1	Significant drop in income levels	34%	Buyers affected by not getting fish	43%
2	Significant drop in fish catches	31%	Significant drop in community incomes	23%
3	Shaken individual welfare	10%	Inability to cater for household needs	10.5%
4	Rise in income (fish prices have gone up)	6%	More profits in fish trade (price of fish has gone up)	10.5%
5	Health issues due to extreme cold while at sea	3%	Increased mobility in seeking income	9%
6	Inability to cater for family needs	3%	Social unrest (theft of livestock) because of poor paying fisheries	3%
7	Decreased access to social services (lack of reliable income)	3%	Do not know	1%
8	Wait for conducive weather	10%		
	Total	100		100

big traders), and had also negatively affected the relationships between the range of other actors in the small pelagic value chain such as fish porters (*wabe-baji*) and processors. At the same time, declining catches meant higher prices of fish for traders and fish mongers. But fish porters were getting less fish to upload, leading to frequent scrambling between men and women. BMU officials in Vyeru explained that in order to reduce the unregulated scrambling for offloading fish, they introduced a registration system for the porters who were given a number recorded on the container used for offloading. In June 2017, there were more than 200 registered containers at Vyeru landing site. Porters were also required to queue as the fishing craft landed and approach them in that order, but decreasing catches disrupted this organized system. This system was also intended to allow fishers or traders to track porters after offloading to minimize incidences of loss.

Other indirect impacts mentioned included increasing theft of small items in people's neighbourhoods. Theft of chickens was said to be on the increase because of what an elderly respondent said "young men do not earn enough from the fisheries nowadays. Hence, they steal small things to sell elsewhere for a living" (MK, Vyeru, 24/11/2017). Fishers were perceived to be the hardest hit by declining catches (mentioned by 43% of respondents - youth of under

18 years (16%), households/families (14%), women (6%), and men in general (mentioned by 4%).

Livelihood vulnerability from changing fisheries

Generally, fishers and the community members expressed their fear of livelihood decline which was aggravated by their inadequacy to cope with changing fisheries. Among the factors noted to influence people's vulnerability included: (i) Perceptions and understanding of risk factors, (ii) Over-reliance on a single livelihood source - the fishery, and (iii) Nature of external support systems.

Perceptions of risk factors

The biggest perceived risk was related to human-induced factors, such as increasing population of fishers, fishing intensification and especially, unregulated patterns of fishing. Although fishers acknowledged that changes in weather patterns have been more frequent and severe over the last 5 years (2012-2017), changes in such natural processes were generally not viewed as significant risk factors to their livelihoods.

Of importance was how the fishers' viewed their own inability to access distant fishing sites due to poor technologies, and how this was perceived as a major hindrance in allowing them to cope with the implications of changes in sea water conditions. Although the

study noted that a few skippers used GPS, which has improved access to desired fishing grounds because of maximized accuracy in targeting distant fishing grounds, they were few, not local, and mostly from Zanzibar. In addition, although changes in the timing of best fishing periods were sometimes still associated with the changing patterns in weather conditions, fishers perceived the latter as natural events and inevitable changes within the sea.

A bigger concern of fishers with regard to unexpected bad weather such as strong winds, heavy rains and unexpected storms, was for their own safety. Poor technologies affected their capacities to prevent and cope with disasters at sea. Most of them did not carry enough safety equipment to cater for the entire fishing crew. In one FGD at Sahare, community members stressed that they needed fibre-glass boats (locally named as '*faiba*') in the belief that these are fast and efficient and able to save fishers during weather disasters (FGD with Skippers, Sahare, 27/6/2017). Vessel wreckage during storms was said to happen now and then, and fishers only had other fishers to save them during such incidents. Hence their insistence on fishing around reefs that were 'sheltered'.

Overreliance on a single livelihood source

The overriding dependence on the small pelagic fishery by local communities limited their ability to cope with changing sea conditions in the recent past. The small pelagic fisheries generated a web of inter-dependence and inter-relationships connecting individual fishers, women, families, traders and other community members. The vibrancy of these relationships could be witnessed during bumper catches. The decline in fish catches however, exposed the weaknesses in these relationships. Many members relied on small pelagic fisheries as the single and most important livelihood source. Very few fishers had another viable source of livelihood (Table 7). Women porters expressed that fish offloading (*ubebaji*) gave

them access to a more reliable and immediate source of income than toiling as a worker in some of the eating places (*mgahawa/hoteli*) or, in farming. The average income as a *mgahawa* worker was about Tshs 2000 (approx. USD 0.8) a day, while a porter could earn up to Tshs 10,000.00 (approx. USD 4.9) a day from the work. *Ubebaji* also gave them more dignity as independent income earners.

Information on changing fisheries

Inadequate capacity in making predictions about the weather, and in identifying locations with the best fisheries in the context of climate-related upwelling conditions, was a major factor that added to the vulnerabilities of these communities. In all three sites it was observed that fishers and fishing communities did not have access to reliable and timely information about weather conditions that influenced changes in the fisheries. Fishers therefore could not effectively take advantage of upwelling locations to maximize their fishing catches.

In this regard, several key institutions had the responsibility to promote the productive use of the fisheries by communities, including enhancing their adaptive capacities to changes. These institutions included national and local government fisheries offices, national weather and transport agencies, grassroots level governance structures such as village governments and the Beach Management Units (BMUs) of Petukiza and Vyeru landing sites, and the sub-hamlet government and Coastal Conservation Committee at Kasera landing site. The study also examined how and from what sources fishers receive weather-related information (Table 5).

It was found that fisheries officials in both Tanga Municipality and Mkinga District did not have a systematic programme for formal communication to small-scale fishers about weather changes (KII, TA, 29/11/2017). In addition, the Tanzania Meteorological Agency (TMA)

Table 5. Fishers' sources of information on weather conditions affecting the sea (November, 2017).

Source	Frequency	Percent
Never been informed	34	38.6
Through the media (radio)	52	59.1
Learn through own experience	2	2.3
Total	88	100

Source: Field data: PEACC Socioeconomics study, May 2017

which is mandated to provide weather forecasts and national climate outlooks was not directly connected to Tanga coastal fisheries. The closest interaction with communities related to information on weather related aspects came from occasional visits conducted by the National Surface and Marine Transport Authority (SUMATRA) to provide education on safety at sea for fishing crews. Fishers at Kasera landing site (Sahare) mentioned that SUMATRA officials had once visited them (in 2016) and distributed some life jackets as part of their awareness raising programmes. They had not paid another visit to the landing site since then. The radio was mentioned as the most resourceful media for weather forecasts, but was unfortunately not always used for fishing trips.

According to the fishers, their association with fisheries officials was occurred in three major ways: *Kukagua* (Inspection); *Kukata leseni* (Licensing); and *Kulipa ushuru* (Paying taxes). The fishers thus felt that they were left to encounter changing conditions of the sea on their own, and were usually not informed or enlightened about strategies to identify more lucrative fishing locations. Hence, they kept on relying on traditional means of weather prediction, '*reading the seas*'. Fishers also complained that they were not adequately supported with efficient fishing vessels to be able to access distant productive areas offshore. Even though they sometimes detected certain locations as possibly lucrative for fishing ground, they failed to take full advantage of these locations because of poor vessels which could not venture offshore.

Adaptive capacity to changing fisheries

Given their experiences of vulnerability, different community groups in the study area responded

differently to changing conditions in the local fisheries, drawing on different assets at their disposal. Despite declining catches, most fishers were hesitant to leave the fisheries and opt for other livelihood activities. Most of the responses indicated an inclination to periodic and 'circular' shifts either in fishing grounds or fishing times, but within the same small pelagic fishery. The responses did not give any indication of a planned reaction to any changes in the fisheries, but rather a more generalized reaction to conditions as they were experienced. The most viable response option mentioned was the need to acquire better seaworthy equipment such as modern fishing vessels (Table 6).

As illustrated above, about 45% of the fishers assumed a resigned attitude to change, while others assumed that more efficient technology would be a better solution. Shifting to other fishing grounds in accordance with changing seasons was also mentioned as a viable option that would allow them to remain in the fisheries.

At the household level there was a combination of intra-household and inter-household adaptation strategies. Women for example, explained that they capitalized on local support systems such as social networks, which included seeking loans from neighbours/relatives, and occasionally asking for relish from a neighbour or fishers for the daily meal; a common practice seen in coastal communities of Tanzania. A less preferred option was to reduce household consumption costs through purchasing cheaper food items or clothing. Other common coping strategies mentioned included putting aside savings (in anticipation of harder times ahead), but since savings

Table 6. Perceptions of fishers and expressed adaptation options to changing fisheries.

Type of response	Percentage
No viable option	45
Seeking seaworthy equipment – modern vessels	30
Seeking business opportunities, credit	9
Shifting from depleted grounds to other fishing sites	7
Consulting and learning from fishers' knowledge on weather	3
Reducing tax rates	2
Keeping savings to cater for bad fishing times	2
Migrating	1
Total	100

depended on the vibrancy of the small pelagic fisheries, this was hardly affordable for poor households. Other households sought alternative income generation activities such as daily paid labour. Investing in other activities such as small businesses was however also difficult because of inadequate capital. Many women voiced this constraint in the FGDs.

The general pessimistic attitude towards viable options was observed to be influenced by people's desire to maintain their engagement with the fisheries. Men were more at risk in accessing viable response options than women in this regard because of the nature of activities in fishing communities. Options such as modern beekeeping or fish farming (currently developed in other coastal communities in Tanga region) were seen as not viable because of their operational requirements and experiences of poor past performance. Similarly, Anderson and Samoilys (2016) note the significant challenges that coastal communities have encountered in promoting alternative livelihood activities with reasons ranging from scale of operations, to viability and sustainability. In view of the generalized vulnerabilities that these communities experienced, the most reliable modes of adaptation were collaborative efforts, but within the same fishing areas (Table 7).

Conclusions

This study examined the experiences and responses of fishers and fishing communities to variability and changes in climate and climate-related phenomena

such as upwelling, and the consequent changes in the productivity of small pelagic fisheries. What is evident is that there are different ways through which fishers communicate about changes in the fisheries, or changes in the conditions of the sea, depending on how it affects their livelihoods. Their increasing experience of fewer catches during the NE monsoon period, which is also believed to be the period of high productivity, raises questions related to fishing capabilities during periods of enhanced wave action and turbulence, suggesting more research is necessary to compare productivity levels between this season and the calm (interchanging) monsoon seasons, which fishers claim to obtain better catches. It is also important to examine whether there is a lag between nutrient enrichment associated with upwelling and enhanced small pelagic fisheries productivity, which occurs during these interchanging monsoon periods, as experienced by fishers.

The study has also shown that, although fishers do not directly understand the relevance of upwelling-related conditions to productivity in the fisheries, their experience of enhanced fisheries productivity is sometimes associated with those areas and periods when upwelling conditions are said to occur. However, given the nature of changing sea conditions due to current influences of climate change, conditions related to upwelling may not be readily comprehensible to fishers whose major knowledge base has been related to natural seasonal weather patterns. Their vulnerability to livelihood decline is possibly due to their inability

Table 7: Modalities of adaptation measures.

	Response option	Level	Gender	Mode
1	Seeking alternative fishing grounds	Individual/Collaborative/Optimistic	Men	Circular
2	Increasing fishing efforts	Individual/Collaborative/Optimistic	Men	Periodic
3	Seeking alternative livelihood options.	Individual/Optimistic	Men, Women	Short-term
4	Compliance to fishing regulations	Authority/Pessimistic	Men	Short-term
5	Using savings	Individual/Pessimistic	Men, Women	Intermittent
6	Seeking support through networking, relatives	Individual/Collaborative/Optimistic	Men, Women	Periodic
7	Not able to do anything different	Individual/Pessimistic	Men	-

to take advantage of more potential lucrative fishing areas because of limited prediction capacities and the lack of relevant scientific information.

In addition, the multiple and varied ramifications that changes in small pelagic fish catches have had across community groups by occupation and gender in the Tanga fisheries illustrates the importance of understanding the small-scale fisheries as a web of associations, within which multiple level vulnerabilities and adaptation capacities can be realized. Indeed, the varying levels of adaptive capacity of the population groups are influenced not only by their different abilities to draw on different resources, but also by their perceptions and hence responses to risk. New experiences open up varying adaptation options for certain population groups within the same fisheries, with positive or negative implications to livelihoods. Limited options are making people to resort to periodic and often short-term measures informed largely by local knowledge of livelihood patterns. The relevance of sharing and integrating experiences and knowledge in current fisheries management is thus of paramount importance.

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