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Cover image: Fisherman pushes his boat along the channels around Inhaca Island, Mozambique (© José Paula)

Local knowledge of fishermen in weather prediction in Moa and Kwale coastal villages, Tanzania

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Abstract

This study investigated local knowledge of fishermen in weather prediction in Moa and Kwale coastal villages, Tanzania. Focus group discussions, seasonal calendars, time line analysis, key informant interviews, questionnaire surveys and documentary reviews were used to gather data. The SPSS programme was used to analyze quantitative data while qualitative data was analyzed using content analysis. Fishermen were found to observe the behaviour of sea water, plants, fish species, sea worms, marine mammals, terrestrial animals, amphibians, human beings, birds, insects, sea rubbish, moon, clouds, rainbow, sun, sea sand, stars and sky, to predict weather change in their localities. Of the many weather parameters mentioned, wind and rainfall were regarded as the most important weather parameters to consider when planning for fishing expeditions. It was also noted that the majority of fishermen are aware of climate change through long term observation of local weather patterns in their localities. Fishermen were found to be able to predict typical weather conditions and productivity seasons throughout a year. However, despite the usefulness of local prediction, this important knowledge is challenged with a number of issues that threatens its existence. The study recommends various approaches to strengthen and sustain the effectiveness of local weather prediction.

Keywords: Fishermen; local knowledge; local indicators; weather prediction; weather parameters

Introduction

Climate and weather issues have been of increasing interest and concern in many countries over recent years. The Inter-governmental Panel on Climate Change (IPCC) (2001) and the Assessment of Impact and Adaptation to Climate Change (AIACC) (2005) reported that climate change and variability will continue to adversely affect water resources, agriculture, forestry, fisheries, human settlements, ecological systems and human health in many parts of the world, including Tanzania.

In Tanzania, about 95% of the total marine catch is from artisanal marine fisheries using traditional vessels and gears. This fishery supports fishermen and large numbers of people processing and selling fish, as well as others who make and repair boats and gears (Jiddawi and Ohman, 2002). Climate change and adverse weather events are threatening this important coastal livelihood activity (Terada, 1968) to the extent that, if not well monitored, may undermine national efforts to attain the Millennium Development Goals (MDGs) and places poverty reduction efforts within fishing communities in jeopardy. Timmers (2012) reported that extreme weather events limit the number of days on which fishing is possible, which may adversely impact the livelihoods of coastal communities. Moreover, extreme weather events may cause accidents to traditional fishing vessels which threaten the lives of fishermen and their fishing equipment. Reliable climate information services and timely seasonal weather forecasts can offer great potential to inform fishing decision making in the face of increasing climate variability and help fishermen adapt to the

changing climatic conditions. However, despite significant progress in the provision of scientific weather forecasts in East Africa, most of the seasonal forecasts are not specific to particular localities and are not reliable (Mahoo *et al*., 2015).

Historically, local communities have used traditional knowledge to understand and predict weather and climate patterns (Kadi *et al*., 2011) through observation and monitoring of environmental changes and behaviour of animals, birds, plants and insects and non–living things such as wind and clouds (EPMS, 2010). The recognition and application of this knowledge is not uniform across communities and differences are rooted on occupations, geographic locations, ethnic origin etc. (Spencer-Oatey, 2012). There is an increasing number of studies on local weather prediction in different parts of Tanzania. It is noted that many of these have been in terrestrial areas focusing on farmers' knowledge. For example, a study by Chang'a *et al*. (2010) revealed how farmers in the South-western Highlands of Tanzania predict rainfall using local environmental indicators and astronomical factors. Kijazi *et al*. (2013) reported on the role of famers' and pastoralists' indigenous knowledge in weather and climate predictions in Mahenge and Ismani wards in Morogoro and Iringa Regions, respectively. Few studies have focused on marine areas. However, Tobisson *et al*. (1998) carried out a study to try and understand how fishing communities in Zanzibar make optimal use of local knowledge of tides and monsoons in their fishing activities. Unfortunately, it was not explicitly reported in this study how fishermen's knowledge is used to predict different weather parameters.

The present study aimed to document fishermen's local knowledge related to weather prediction in some coastal communities of Mkinga District in Tanga Region, Tanzania, and recommend the best approaches to sustain the effectiveness of local forecasts. The study was considered important since local knowledge is under threat of disappearing due to many reasons including the lack of systematic documentation, and coordinated research to investigate its accuracy and reliability, and the death of old people who are the main custodians of the knowledge (Mahoo *et al*., 2015). In addition, the disappearance of some living indicators due to anthropogenic activities and the effects of climatic change, are also challenges to traditional weather forecasting (Risiro *et al*., 2012; Kijazi *et al*, 2013).

Materials and methods

Description of Study Sites

Mkinga District, which is found in Tanga Region, is the northernmost part of the coast of mainland Tanzania, and borders Kenya. The district has an area of 2,948 square kilometers and a total population of 118,065 (NBS, 2013). Historically, Tanga coastal communities were reported by Wells *et al*. (2007) to hold considerable local knowledge of natural resources and their environment. However, no detailed studies on fishermen's local knowledge in weather prediction has been conducted and documented. Two coastal villages; Moa and Kwale (Fig.1), were purposely selected for the study based on their proximity to the ocean, and because they are established villages that practice a diversity of traditional fishing methods.

In a recent village census (2014), Moa village had 1,512 inhabitants with 362 households. The main tribes are Segeju and Digo. Fishing, agriculture (cassava and rice), and small businesses such as kiosks mainly selling raw and cooked food, are the main livelihood activities in the village. The majority (about 90%) of fishermen practice hook and line fishing. Other fishing practices are net fishing (gill net), gleaning for invertebrates, and diving for octopus and lobsters. In 2014, Kwale village had 1,117 inhabitants with 236 households. The main tribes are Digo and people from Pemba Island. Livelihoods include fishing, farming (maize, cassava, and coconut), livestock keeping (cows, goats, sheep, chicken and donkeys) and some formal employment. The main fishing practices in the area are diving for octopus, basket trap fishing, net fishing and hook and line fishing.

Data Collection and Analysis

Data collection started in November 2014 and ended in March, 2015. Both qualitative and quantitative social research methods were applied with the former approach being dominant. Qualitative data were obtained through Focus Group Discussions (FGDs), Seasonal Calendars, Time-line analysis, and Key Informant interviews. Quantitative data were obtained through questionnaire surveys using both closed and open-ended questions. In all research methods questions asked focused on local indicators and their interpretations by fishermen in weather prediction, fishermen's perceptions about the changing climate, challenges of depending on local weather prediction, and views on the potential of using local predictions. In addition, relevant published and unpublished documents from websites and government offices were reviewed and synthesized to complement and validate field data.

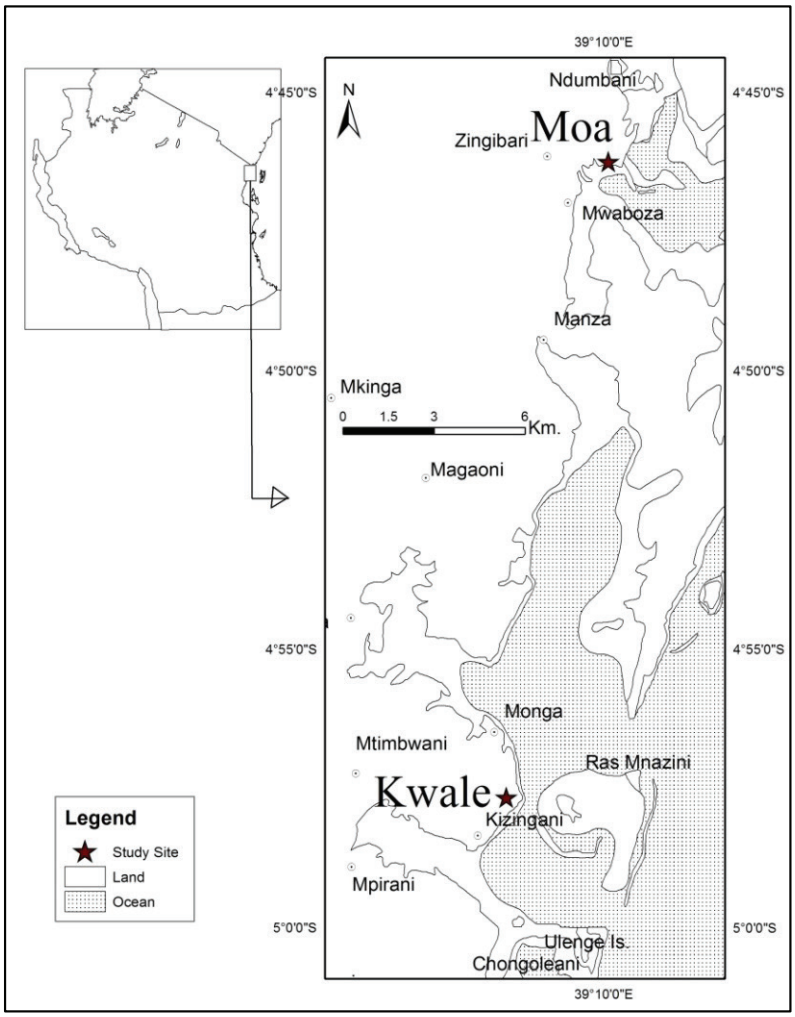

Figure 1. Map of Mkinga District showing the study sites (Source; Institute of Marine Sciences Database).

One FGD was carried out in each study village. The groups consisted of 5 and 4 fishermen of different ages and different gear types, for Moa and Kwale villages, respectively. The mix of participants of different categories was appropriate in order to capture all the necessary information needed for the study. Saunders *et al.* (2007) recommends that a typical FGD should involve 4 to 12 participants depending on interviewer skill and subject matter. During FGDs, seasonal calendars and time-line analysis were conducted to solicit further information on local weather patterns. In these participatory methods, participants were asked to determine weather patterns such as the months of rainfall and strong wind, and their implications. In addition, time line analysis was used to list all notable weather events and their associated dates of occurrence.

The questionnaire survey was administered to 30 fishermen in each study village. Respondents were chosen based on the requirement that they were practicing traditional fishers and had been involved in traditional fishing activities for at least 10 years. In rural coastal areas, traditional fishers who have been involved in fishing for a lengthy period are assumed to have more experience on local weather forecasting, and have observed many weather events. Three stage sampling was employed in the selection of respondents. In the first stage, fishermen who use traditional fishing methods were identified. In the second stage, traditional fishermen that have been involved in fishing for 10 years or more were identified. In the third stage, 30 traditional fishermen who have 10 years or more of fishing experience were randomly selected from each study village for the questionnaire survey. According to Bailey (1994), a sample of 30 respondents is sufficient for statistical analysis irrespective of the population size.

In-depth interviews were done with Key Informants (Village Leaders and Village Elders). In addition, the Tanga Meteorological Station Manager was

interviewed to explore his views on modern weather prediction, to gauge his perception on the relevance of local weather prediction, and to obtain his recommendations for improved weather predictions at the local level.

Quantitative data collected from questionnaire surveys were analyzed using the Statistical Package for Social Sciences (SPSS) to generate descriptive statistics (percentages). Qualitative information from Focus Group Discussions (FGDs), Seasonal Calendars, Timeline analysis, and Key Informant interviews were analyzed using content analysis whereby the text was coded into manageable categories on a variety of levels - word, phrase, sentence, or theme; then inferences were made about the messages within the texts.

Results and discussion

Local Indicators Used by Fishermen in Weather Prediction

The study found that fishermen have their own knowledge to predict weather conditions. Table 1 summarizes the indicators used by fishermen to predict the weather. In both study villages it emerged that fishermen rely on physical observation and behavior of plants, marine and terrestrial animals, insects, birds, human beings, meteorological indicators (eg. clouds), astronomical objects (eg. stars and moon) and other non-living things such as sea rubbish, to predict upcoming weather. They observe a combination of these local indicators to inform fishing decisions especially on what, where, when and how to fish. Many of the listed indicators were used to predict rainfall and wind (strength and direction), which might occur within a short period of time, usually within the next few hours, to one week. Other indicators mentioned are used to predict wave heights, temperature and water current speed.

Fishers identified the behaviour of plants, such as the wilting of mangrove flowers (*Sonneratia alba*) and the drying-up of trees as indicators of change in wind direction associated with the southeast to northeast monsoon. Fishermen translated this period as conducive for fishing, especially for those using traditional fishing gears. Other studies in Tanzania and other parts of Africa also report that plant phenology is commonly used in predicting weather events. For example, a study by Chang'a *et al*. (2010) in the south-western highlands of Tanzania established that farmers use the phenology of trees such as *Erythrina abyssinica* and *Brachystegia speciformis* to predict rainfall. A study by Elia *et al*. (2014) also indicated that some farmers in Dodoma and Singida villages make use of plant phenology such as the sprouting of tree leaves, flowering, and plant growth to predict rainfall onset, and a good or bad crop year. In Bukina Faso, flowering of fruit trees and the occurrence of good fruit yields of trees such as mangos were mentioned as the indicator of abundant rainfall associated with good harvests (Roncoli *et al*., 2002).

Fishermen interpreted meteorological indicators such as the appearance of clouds as signs of particular weather conditions in the next few hours or days. For instance, the formation of clouds in the southeast; red clouds at sunset; clouds associated with strong winds and thunder from inland; formation of cloud cover throughout the sky; and the formation of dark clouds in just one area, were all reported to predict heavy rainfall accompanied by strong winds in the next few hours/days. When these conditions are observed, artisanal fishers postpone their fishing plans until further indicators are noticed. Apart from fishing communities, farming communities also use cloud appearance as an indicator of rainfall. A study by Okonya and Kroschel (2013) undertaken in selected villages in six regions of Uganda found that farmers predict the start of the rainy season by observing the appearance of clouds in the morning and evening.

Behaviour of some marine and terrestrial animals, and human beings, was also used to predict a change in weather parameters. During focus group discussions, fishermen explained that the abundance of mullet fish (*Mkizi*) is a sign that the northeast monsoon wind is about to start. The northeast season was said to be associated with calmness, short rains and fairly good catches. Fishermen also said that a lot of sea worms on the surface of the sea is an indication of high temperature in the next few days. Hot periods were related to unpredictable rains, winds and currents, but were associated with a fairly good catch. The presence of marine mammals, particularly dolphins, when jumping and splashing their tails in the water, is interpreted as a sign of calmness in the sea which is associated with increased temperature. Terrestrial animals also provided signs that indicated the upcoming weather. For example, cows running with their tails upward is an indication of rainfall in the next few days. Similarly, when people feel pains throughout their bodies or numbness in their limbs, this is an indication that there will be rainfall in the next few days.

Table 1. Local indicators/knowledge used in predicting weather changes in Moa and Kwale fishing villages.

Indicator	Indicator Description	Weather parameter predicted
Sea water	Formation of sparks-like in sea water	Indication of rainfall associated with strong wind in the next few hours or days
	Presence of yellow or red seawater oily like	
	Movement of seawater to the northern side	
	Sudden change in water movement from normal to high speed	
	Mixing-up of water with soil in the sea	Indication of high water waves
	Spring tide periods (Moon days 14 – 15 and 29 – 30)	Prediction of high water current speed
	Calm spring tide	Indication of increased temperature
Plant Phenology	Shading of mangrove flowers (*Sonneratia alba*)	It is time to turn into northeast monsoon wind
	Standing of mangrove seeds (*Rhizophora mucronata*) in large number around the intertidal area	Indication of rainfall in the next few days
	Shading of flowers and leaves of a wild fig tree	
	Sprouting of tree leaves	Indication of the start of southeast monsoon wind
	Dry-up of trees.	Indication of the start of northeast monsoon wind
Fish species	Availability of many mullet fish (*Mkizi*)	It is time to turn into northeast monsoon season
Sea worms	Presence of sea worms on the surface of seawater	Indication of high temperature
Marine mammals	Jumping of dolphins while splashing their tails in the water	The sign of calmness in the sea which is associated with increased temperature
Terrestrial Animals	Cows running with their tails upward	Indication of rainfall in the next few days
Amphibians	Cheeping of frogs continuously	
Human beings	Feeling of pains throughout the body especially in stitched areas	Indication of rainfall in the next few hours or days
	Feeling of numbness	
Sea rubbish	Appearance of rubbish (reddish line) along intertidal water	
Moon	Red and round moon	
	Circular shade surrounding moon	
	Thin and bright moon	Indication of strong wind

Indicator	Indicator Description	Weather parameter predicted
Insects	Appearance of small black ants in large numbers	Indication of sunny days in the next few days
	Appearance of red headed ants and safari ants from the ground	Indication of rainfall in the next few days
	Appearance of red insects in the farms	
	Entering of safari and small black ants into houses	
	Flying of bees from south to north side	Indication of the start of northeast monsoon wind
	Flying of bees from north to south	Indication of the start of southeast monsoon wind
Clouds	Formation of cloud at the southeast side of the study villages	Indication of heavy rainfall associated with strong wind in the next few hours/days
	Dark cloud cover leaving only a small space uncovered by clouds	
	Red clouds formation during sun set	
	Cloud formation associated with thunder and strong wind from land side	
	Dark cloud formation in one area	
	Fast formation of clouds	Indication of rainstorms in the next few hours
	Appearance and fast movement of clouds by the sea side	Indication of high speed wind in the next few hours
	Formation of dark clouds throughout the sky	
	Formation of dark clouds by the sea side (at the lower level)	Indication of a storm in the next few hours
	Formation of clouds with the shape of an animal	
	Formation of light red clouds	
Rainbow	Appearance of a quarter rainbow (*Kisiki*) on the southern or western side which stays for less than an hour	Indication of heavy rainfall associated with strong wind and thunders in the next few hours or days
Sun	Presence of wide sun rays	Indication of rainfall in the next few hours or days
	Increased heat	
	Red sun during sunrise	Indication of high speed wind in the next few hours
Sea sand	Jumping of sea sand during rising of water waves	Indication of rainfall in the next few hours/days

Indicator	Indicator Description	Weather parameter predicted
Birds	Flying of bats from south to north	Indication of the start of northeast wind season
	Flying of bats from north to south	Indication of the start of southeast wind season
	Appearance of many hawks '*mwewe*'	Sign of calmness to the sea '*umande*'
	Appearance of small bats '*popo nundu*' from upland to the sea side	
	Non-stop cheeping of a kingfisher, a bird locally known as 'M*tililil*'	Indication of rainfall in the next few hours/ days
	Flying of small groups of white birds flying and cheeping	
	Flying of many birds at high sky	
	Passing of a bird (*Mwalukombe*) around the trees (especially around mangrove trees) at a high height while cheeping	Indication of calm season associated with increased temperature
	Passing of a bird (*Mwalukombe*) around the trees (especially mangrove trees) at a lower height while cheeping	Indication of strong wind in the next few days
	Cheeping of birds '*kozi*' around the trees	
Stars	Blinking of small stars	Indication of rainfall associated with strong wind in the next few hours/ days
	Assemblage of about ten stars in a group	
Sky	Clear sky	Indication of high temperature

Insects and birds were also local indicators in weather prediction. The appearance of many small black ants indicates sunny days will follow, while the appearance of red headed ants and safari ants from the ground, and the entering of safari and small black ants in houses, indicates the onset of a period of rain. When bees and bats fly from south to north, this is an indication of the start of northeast monsoon winds, and when they fly from north to south this indicates the start of southeast monsoon winds. The appearance of many hawks and small bats over the sea and the flying of a bird known as '*mwalukombe*' at the high altitudes signify the onset of calmness ('*umande*') in the sea. These signs indicate that artisanal fishermen should get prepared for a fishing expedition. However, when '*mwalukombe*' flies at a lower altitude around the trees (especially mangrove forests), this signifies the start of strong wind in the next few hours or days. This is a sign of upcoming danger in the sea due to strong wind.

Unique behaviour of astronomical objects such as the moon and stars was reported to indicate seasons in some cases. Fishermen elaborated that when the moon becomes red and round or when surrounded by a circular halo, or when it is thin and bright, and when small stars are blinking or assemble as a small group in one place, that this signifies that in few days there will be rainfall associated with strong wind. This is a very dangerous period for artisanal fishermen who use traditional fishing vessels and gears. They would then postpone fishing activities until the onset of a calm period.

Fishermen's Perceptions on Climate Change

Perception of fishermen on climate change over the past 10 years was assessed. As shown in Table 2, of the 60 respondents interviewed, the majority (98.3%) were aware of climate change in their localities. They relate climate change to long-term changes in weather

patterns such as rainfall intensity, rainfall periods, monsoonal wind periods and wind speed, occurrence of storms, temperature, and changes in the water currents and waves.

Since local people detect climate change through observing local weather patterns (Howe *et al*., 2013), this study asked respondents about the long-term trend of different weather parameters in their area over the past 10 years (Fig. 2). In both study sites, the majority of respondents (96.7%) reported a decrease in rainfall intensity and 60% perceived a change of rainfall seasons. A nearly equal number of respondents observed both an increase and decrease of wind speed in the southeast and northeast monsoons, while the majority (56.7%) observed a slight change in wind direction. Wave height and current speed were perceived to have increased as observed by 46.7% and 53.3% of respondents in the two villages, respectively. The majority of respondents (80%) rarely observed storms in the study area. In addition, the majority of respondents (86.7%) indicated that temperature has been increasing over the past 10 years.

Since wind and rainfall were mentioned as the most important weather parameters to understand before deciding to embark on fishing expeditions, fishermen based their explanations on long term experience of these two parameters. Southeast monsoonal winds were reported to now last longer as compared to 10 years ago. One fisherman said "*Nowadays, you may find that it is supposed to be a calm wind period - a period of inter-monsoonal wind (changing winds from southeast to northeast winds) but strong southeast winds may still prevail*". These changes have implications to fishermen's lives and livelihoods. An extended period of strong wind poses risks to fishing activities, impairing livelihoods and the lives of people at sea.

On another note, fishermen described the long term observed changes in rainfall intensity and the major rainfall seasons (short rains - *Vuli* and long rains - *Masika*). During focus group discussions at both study sites, fishermen reported that the long rain season is now becoming shorter and the short rain season is becoming longer. Fishermen went so far as to report that nowadays, even a little rainfall may cause flooding. Fishermen linked rainfall with fish availability and farm crops. For instance, in the past, they reported that they caught large quantities of anchovy/sardines (*dagaa*) during the short rains period (October – December). This is no longer the case, with sardines nowadays mostly available during the long rains (March – May). Related to this, unpredictable rains means that decisions about when to farm are more difficult to make. These changes create confusion among fishermen, who are mostly also farmers, because of uncertainty about what and when to fish and/or farm.

As a result of their long-term experience of weather patterns, fishermen established that nowadays the climate has changed and is already impacting their fishing operations. With the prolonged southeast wind, coupled with other extreme parameters such as strong currents, high waves and heavy rainfall, the ocean becomes unsuitable for fishing, especially for those using traditional fishing gears and vessels. In these periods, many fishermen postpone fishing activities and this impacts their livelihoods. However, changes in some parameters may also be beneficial to fishers, especially to those using modern fishing equipment. For example, Bezerra *et al*. (2012) reported that the transport of water induced by strong wind performs an important role in the circulation of the ocean. This causes vertical water movements (upwelling) which bring nutrients to the surface that favor the development of phytoplankton which attracts fish shoals.

Furthermore, this study found that through repeated observation of weather events, fishermen are able to predict typical weather conditions and productivity seasons throughout the year, as indicated in Fig. 3. This includes, for example, months of weak and strong rainfall, strong wind and calm periods, periods of lower and higher fish catches, and good farming

Table 2. Awareness of respondents of climate change in the study area.

Perception status	% Responses		
	Moa (n = 30)	Kwale (n = 30)	Total (n = 60)
Yes	100.0	96.7	98.3
No	0.0	3.3	1.7

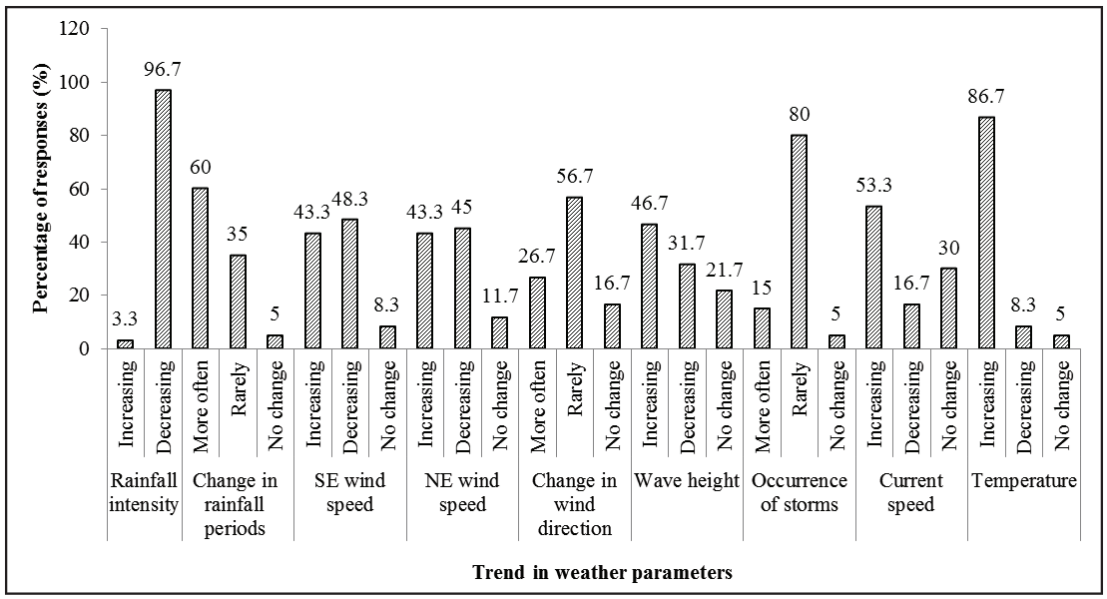

Figure 2. Fishermen's perceptions of trends in different weather parameters over the past 10 years.

seasons. This local knowledge of annual weather patterns helps them to decide when, how and where to fish, and to conduct other livelihood activities in an appropriate manner.

Challenges facing Local Weather Prediction

Despite its usefulness, fishermen identified a number of issues which limits the wide usage, and threatens the existence of, local weather prediction. Table 3 summarizes the challenges associated with depending on local weather predictions, as identified by fishermen. Of the seven challenges mentioned, the existence of few people with the local knowledge to predict the weather (65.0%), uncertainty over the accuracy of local weather predictions (41.7%), and the lack of close monitoring of local indicators (38.3%), received the most responses. In both study areas, it was realized that many elders and fishermen who are experienced in local weather prediction have passed away without transmitting their knowledge to the younger generations. This is coupled with a decrease in the belief in local knowledge and its practices, especially by young people who perceive traditional knowledge as an obsolete belief system. Moreover, the current

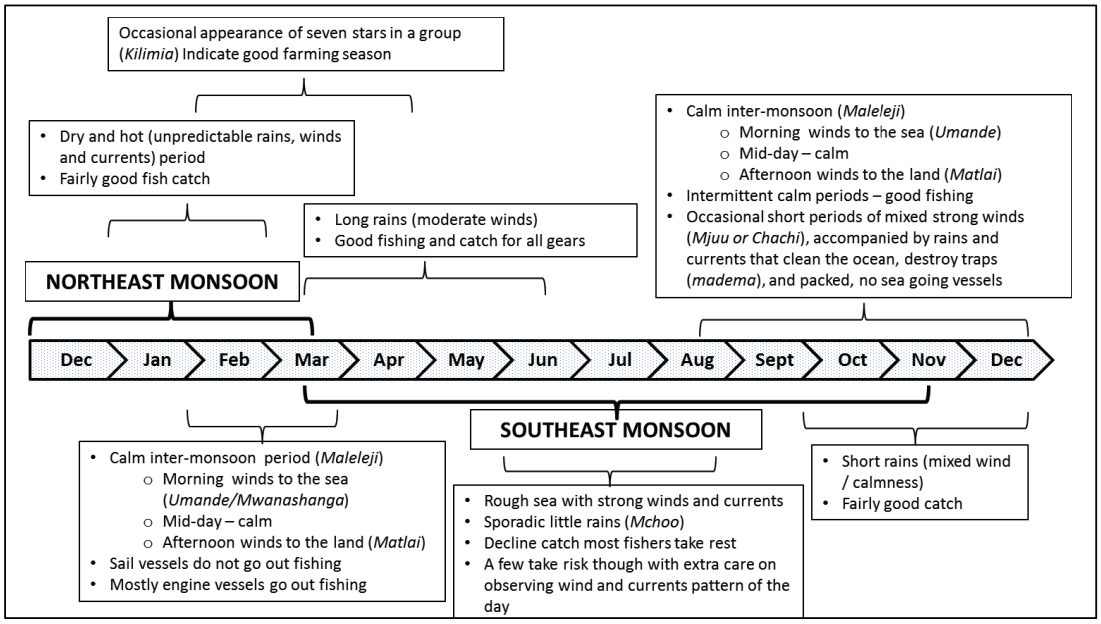

Figure 3. Seasonal calendar of weather parameters in the study villages, based on local knowledge.

Table 3. Multiple responses on the challenges of depending on local weather predictions.

Challenges	% Responses (n = 60)
Few (elderly) people with local knowledge to predict weather	65.0
Close monitoring of local indicators	38.3
Uncertainty of local weather prediction	41.7
Not better than during the past	8.3
Absence of cooperation between local and scientific forecasters	8.3
Changes/disappearance of local indicators	10.0
Disrespect of local knowledge	5.0

uncertainty about local predictions is attributed to the disappearance of some living indicators that were used in weather prediction. It was observed that some plant and animal species that were used to predict weather patterns are now endangered or extinct. For instance, dolphins which are used to predict calm condition in the sea, are now not often found in the area. Kijazi *et al.* (2013) reported similar findings in that one of the challenges facing local forecasting in Mahenge and Ismani wards is the disappearance of indicators such as some bird and fruit tree species.

Concluding remarks and recommendations

This study provided an understanding of how fishermen in the Moa and Kwale communities make use of local knowledge to predict weather. This knowledge is very important to them in planning their fishing expeditions. Of the many weather parameters, wind and rainfall were regarded as the most important to consider when planning to go fishing. As a result, many local indicators identified were related to the prediction of wind and rainfall (intensity and periods). Fishermen rely on physical observation and behavior of the sea, plants, fish, sea worms, marine mammals, terrestrial animals, amphibians, human beings, birds, insects, sea rubbish, moon, clouds, rainbows, sun, sea sand, stars and sky, to predict weather conditions in the near future and to and decide on their actions.

Furthermore, the results show that many fishermen are aware of the changing climate through long term observation of local weather patterns. Also, through long-term observation, fishermen were able to predict typical weather conditions and productivity seasons throughout the year. This finding may have important implications to fishermen. Through long-term observations of weather patterns, fishermen develop adaptation measures to cope with the changing climate because they know when, how and where to fish, and conduct other livelihood activities such as farming.

Despite the usefulness of local weather and climate prediction, this important information is challenged by a number of issues that lessen its reliability and threaten its sustainability. To enhance and sustain its effectiveness there should be: (1) strong cooperation between local and scientific weather prediction experts; (2) increased awareness programmes on the application of local weather information in the planning of fishing activities; (3) recognition of local weather experts by the government; (4) further documentation of local weather information in other coastal areas; and (5) establishment of at least one meteorological station in each District to compare local and modern weather information at the local level. This study also recommends further investigation on how local and scientific weather experts can cooperate to provide reliable and acceptable weather information that is useful to local fishermen.

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