Integrating Indigenous Knowledge with Scientific Seasonal Forecasts for Climate Risk Management in Lushoto District in Tanzania

Working Paper No. 103

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Abstract

Improving food security needs appropriate climate related risk management strategies. These include using climate information to guide farm level decision-making. Progress has been made in providing climate services in Tanzania but there are significant gaps with regard to downscaled location specific forecasts, as well as generating timely, reliable and user friendly information. Majority of the farmers have been using indigenous knowledge (IK) forecasts to predict weather through observing the behavior of large animals, birds, plants, insects, and the solar system. IK is not often documented and is mainly sustained from one generation to another through oral history and local expertise, creating a wide inter-generational gap between its custodians and the young people. This study identifies and documents existing IK in weather forecasting in Lushoto district, northern Tanzania, and aims at promoting the integration of IK and scientific weather forecasting for climate risk management. Historical rainfall data was used in combination with data collected through household surveys, focus group discussions and key informant interviews. Majority of the farmers (56%) indicated that weather forecasts using IK were more reliable and specific to their location compared to scientific forecasts. Comparison was made of the seasonal March-April-May (MAM) forecasts in 2012 from IK and Tanzania Meteorological Agency (TMA), with both approaches predicting a normal rainy season. The IK forecasts were, however, more reliable in the long rainy MAM season compared to the short rainy October-November-December season. To improve accuracy, systematic documentation of IK and establishment of a framework for integrating IK and TMA weather forecasting is needed. There is also a need to establish an information dissemination network and entrench weather forecasting within the District Agricultural Development Programmes.

Keywords

Indigenous knowledge; weather forecasts; climate risks; rainy season; agriculture

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Table of Contents

Acronyms

DADPs	District Agricultural Development Plans
DALDO	District Agricultural and Livestock Development Officer
FGDs	Focus Group Discussions
GDP	Gross Domestic product
IK	Indigenous Knowledge
MAM	March April May
OND	October November December
NGOs	Non-Governmental Organizations
TMA	Tanzania Meteorological Agency

1. Introduction

Smallholder farmers in many parts of East Africa face numerous challenges. These include declining soil fertility and crop yields, poor market access, declining land sizes and constrained access to land. Household food insecurity and poverty level are also increasing (Kristjanson et al. 2012, Thornton et al. 2011). These challenges are likely to worsen as climatic conditions change and become more variable, mainly due to the limited adaptive capacity and low levels of development. Moreover, limited access to available technological options and information further heighten vulnerability to climate stresses. Indeed, Africa's climate is warmer than it was 100 years ago and model-based projections of future greenhouse gas induced climate change for the continent project that this warming will continue and in most scenarios, accelerate (Hulme et al. 2001, Christensen et al. 2007). In Lushoto district in Tanzania, dry spells, floods and unpredictable rainfall have increased, negatively affecting agriculture and food security. These problems are compounded by high poverty rates (with about half of the population living below the poverty line) and low agricultural productivity (Lyamchai et al. 2011). While farming is the primary source of food and income in Lushoto, the farms are not diverse and show very few agricultural innovations.

Use of improved agronomic practices can help increase on-farm productivity and contribute to reduction in land degradation. However, reliable climate information services and timely seasonal weather forecasts can offer great potential to inform farm-level decision making in the face of increasing climate variability. This can improve management of climate-related risks in agriculture, and therefore help farmers adapt to the changing climatic conditions. Despite significant progress in provision of scientific weather forecasts in East Africa, most of the seasonal forecasts are not specific to the localities and there are difficulties in accessing forecasts on time.

Local communities in Africa have continued to rely on indigenous knowledge (IK) to conserve the environment and deal with natural disasters (Chang'a et al. 2010, Egeru 2012). They have generated a vast body of IK on disaster prevention through early warning and preparedness (Roncoli et al. 2002). The use of scientific and indigenous climate forecast information for farm level decision making has been reported in Kenya, Mozambique and Zimbabwe (Lucio 1999, Ngugi 1999). Also, Shumba (1999) documents the integration of contemporary and indigenous climate forecasting for coping with drought in Zimbabwe. Before the establishment of scientific weather forecasting, older generations especially in the rural areas in Tanzania have largely relied on IK to predict weather (Kadi et al. 2011) through observation and monitoring the behavior of animals, birds, plants and insects (Kihupi et al. 2002, Mhita 2006, Acharya 2011). In spite of all these benefits, weather forecasting using IK has challenges and these include lack of systematic documentation of the knowledge, lack of coordinated research to investigate its accuracy and reliability, and when old people who are the main custodians of the knowledge pass away, it is lost.

Systematic documentation and subsequently integration of IK in seasonal rainfall forecasting is one of the promising initiatives that need to be explored. The aim of the study was to promote the integration and utilization of IK and scientific weather forecasting to improve farmer decision-making and management of climate risks. The specific objectives were:

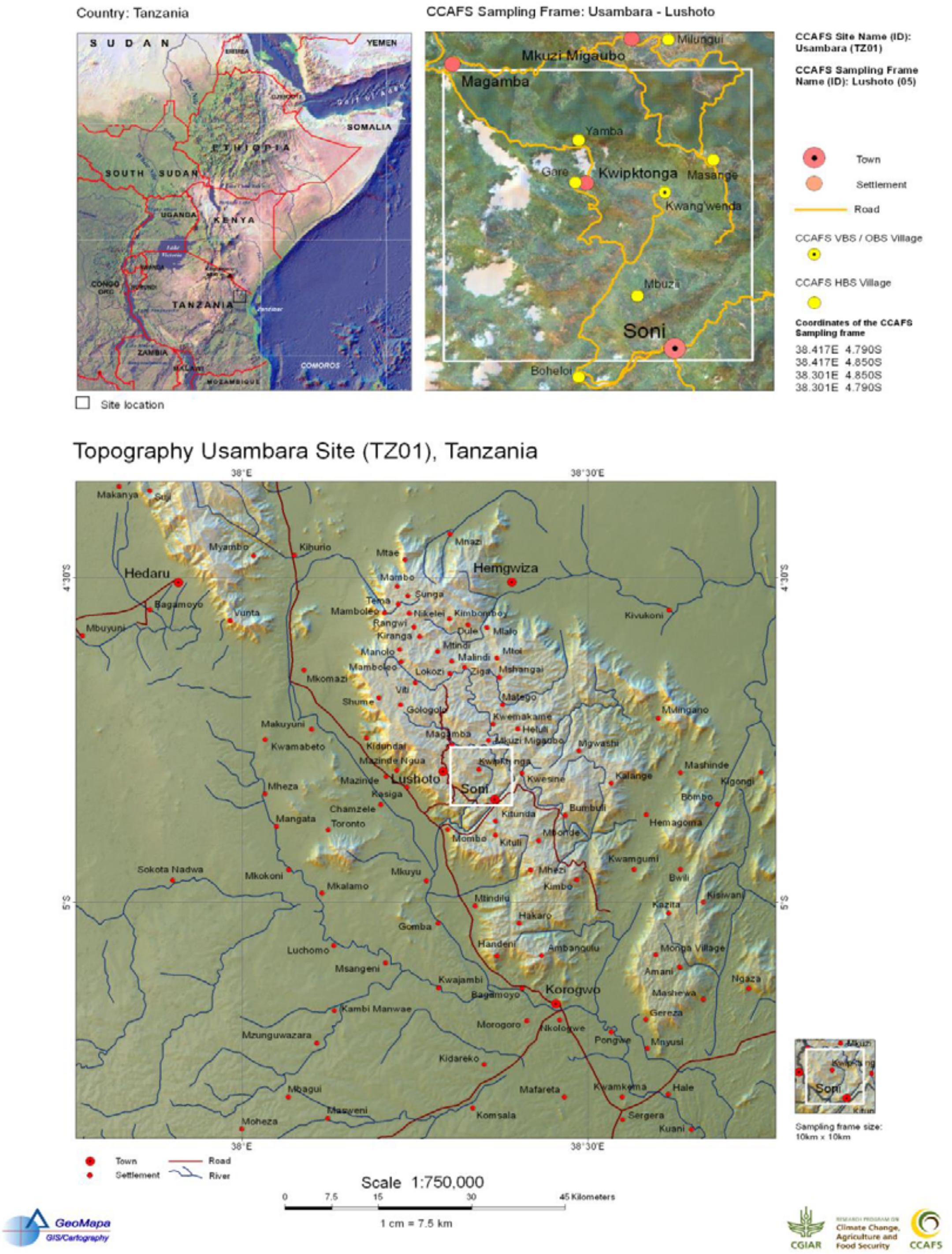
- To identify and document existing IK in weather forecasting practices;
- To establish IK weather forecasting zones and teams; and
- To operationalize the integration and dissemination of IK and scientific weather forecasts.

2. Method

The study was carried out in Lushoto District, Tanga Region in Tanzania (Figure 1). Lushoto is one of the six districts in Tanga Region, with an approximate land area of 3,500 km^2. The altitude ranges from 200 m in the lowlands to 2000 m in the highland areas. Average annual rainfall ranges from 400 mm in the lowlands to 1800 mm in the highlands, with a mean annual temperature of 16°C and humidity of 70%. According to the 2002 national census, the total population in Lushoto district was 419,970. The Sambaa tribe is the dominant ethnic group in the district followed by Wapare and Wambugu and other smaller ethnic groups. The major economic activity in the district is subsistence farming of vegetables, fruits and maize with the majority of the population living within its rural areas.

Data were collected from seven villages — Boheloi, Gare, Kwang'wenda, Masange, Mbuzii, Milungui, and Yamba, through household surveys. The study villages were spread in three administrative wards (Gari, Kwai, and Mbuzii). Respondents were randomly selected from each of the seven villages. The survey data were complimented with information from key informant interviews and focus group discussions (FGDs) that were carried out in three of the seven villages. The Lushoto district agricultural extension officers worked with village leaders to identify key informants who were knowledgeable on IK in the local community. They held meetings with the identified resource persons in their respective villages to discuss weather forecasting using IK. Following the interviews, the seven villages were grouped into three IK teams representing the upper, middle and lower zones. Each team consisted of seven people whose selection was based on gender and specific IK expertise such as plants, insects, animals, wind, moon and stars. The teams were trained on recording weather forecasts, and a schedule was agreed upon where they could meet regularly every two weeks to carry out the IK weather forecasting.

Figure 1. Map of Lushoto site



Source: CCAFS

In total, 77 respondents were interviewed across the seven villages of which 67.5% were male and 32.5% were female. Majority of the respondents (75.3%) had primary school education, with at least 4% having attained secondary school education. Most of the respondents (45.5%) were over 50 years of age with 44.2% being between 36 to 50 years of age and only 9.1% were below 36 years of age. The household data captured information on indicators and reliability of IK, awareness of climate change and variability, sources and access to climate information, occurrence and severity of extreme climate events, risks and vulnerability of different sectors of the economy to climate change. Historical data from Tanzania Meteorological Agency (TMA) over the period 1922–2012 was used to analyse annual rainfall trends, variability and seasonal characteristics.

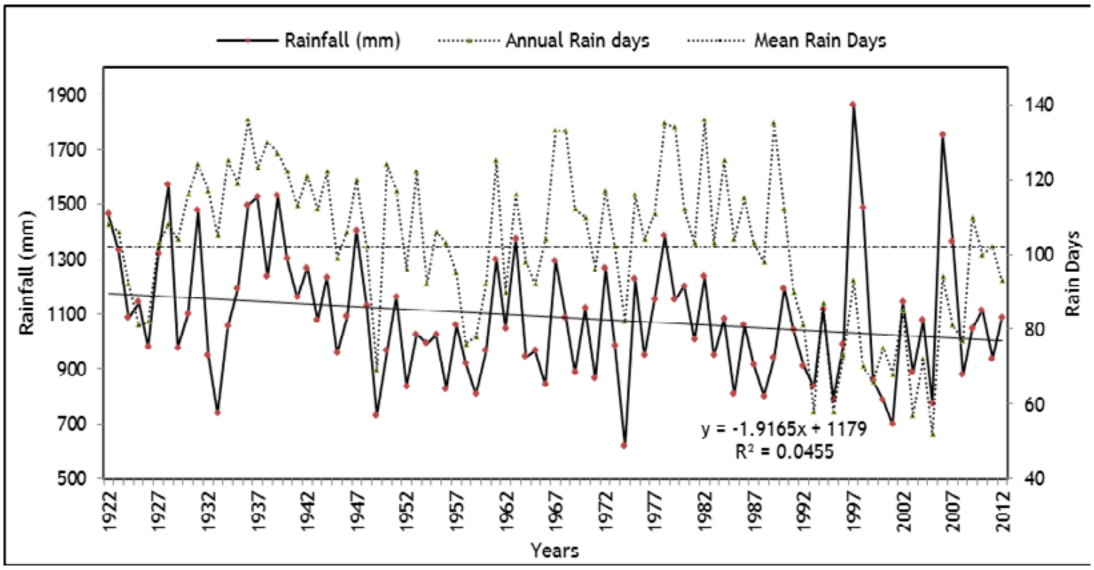
Data collected through household survey were analysed using SPSS version 21. Information collected from the key informants and FGDs was grouped together and synthesized according to the checklist of questions and interpreted.

3. Results and discussion

3.1 Annual and seasonal rainfall patterns

The daily rainfall data for Lushoto for the period 1922 to 2012 obtained from TMA shows a decreasing trend though not significant (Figure 2). The mean annual total rainfall over this period was 1,079 mm with an average of 102 rainy days (Table 1). The highest rainfall amounts were recorded during the El-nino years of 1997 (1,862 mm) and 2006 (1,754 mm). The driest year was in 1974 with an annual mean rainfall of 619 mm.

Figure 2. Lushoto long term annual rainfall trends



Source TMA

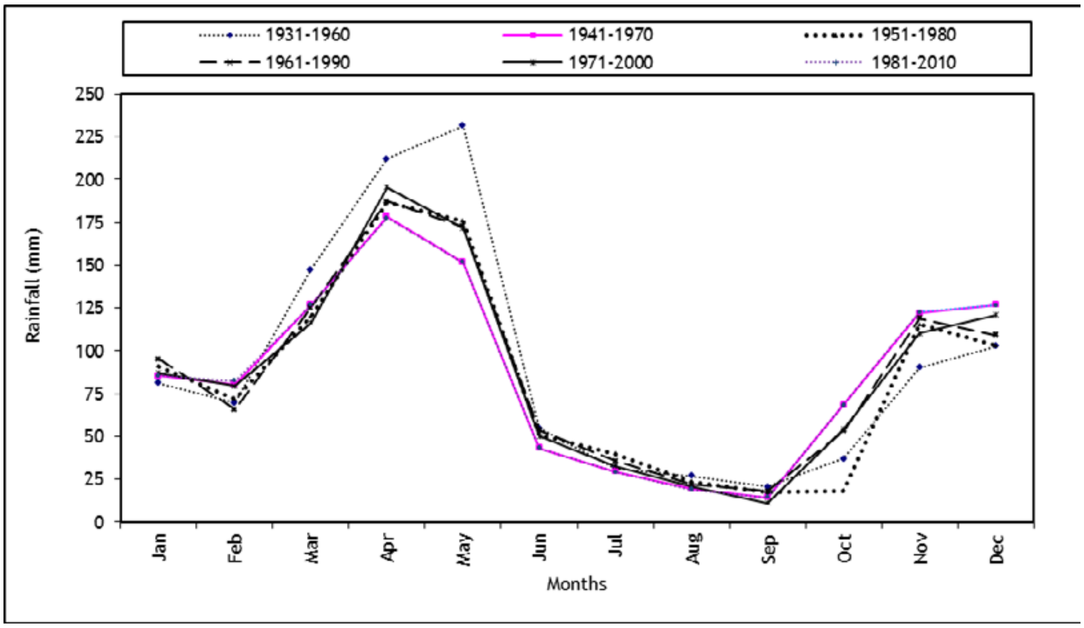
The bimodal seasonal rainfall pattern in Figure 3 shows the long rainy season (*masika*) which occurs from March to mid-June, and the short rainy season (*vuli*), which occurs in the months of October to December.

Table 1. Lushoto mean monthly rainfall (mm) for the period of 1971-2000

Month	Mean rainfall
January	87.0
February	74.5
March	136.1
April	199.8
May	192.9
June	52.4
July	34.9
August	23.5
September	17.6
October	50.6
November	111.5
December	111.4

Source: TMA

Figure 3. Comparison of 30-year period monthly rainfall patterns

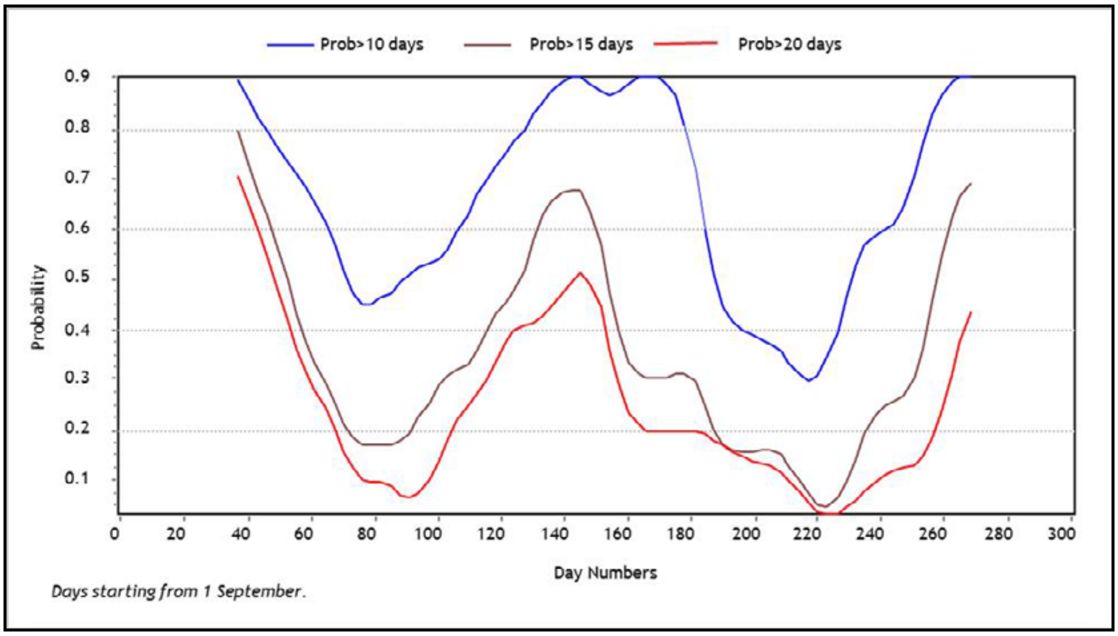


Source TMA

The *masika* season records more rainfall than *vuli* season, with peaks in April (190 mm) and November (110 mm) respectively. The mean rainfall during *masika* is 527.8 mm, and *vuli* is 272.4 mm. Changes in the rainfall amounts received during both seasons is clearly evident with a slight shift toward late onset and early cessation of the rains. The *masika* seasons of 1931 to 1960, for example, experienced late onset (in May) as compared to the other periods where the peak is in April. Over the period 1981-2010, the seasonal trends show a decrease in rainfall amounts during *masika* season and increased amounts during *vuli* compared to the previous 30 years.

The risk of having longer dry spells (greater than 10, 15 or 20 days) during rainfall season in Lushoto is not so high (Figure 4). The risk is below 50% at the peak of both *vuli* and *masika* seasons and increases gradually before and after the peak of the rainfall seasons.

Figure 4. Probability of dry spell in Lushoto



Note: Day 1 represents September 1, Day 85 (mid-*vuli*) for November 24 while Day 220 (mid-*masika*) is April 6

3.2 Farmer awareness of climate change and variability

Almost all the respondents (98.7%) were aware of the changes in climate, with 11.7% of the respondents much better informed on climate change and variability. These results were consistent with the responses from focus group discussions with the key informants. Findings from the key informant discussions show that the rains were reliable in the 1940s to early 1970s, with either few or no crop diseases and pests, and it was relatively cooler. Over 95% of the respondents perceived climate change as the main cause of the agricultural problems and unpredictable and unreliable rainfall. Climate change led to the drought and sometimes flood events, poor crop yield, loss of income and hunger, and damage to property and life.

In the early periods (1940s-1970s) when rains were reliable, farmers in Lushoto used to grow many varieties of fruits and crops with high yields. However, with the changes in climate, most of the indigenous cultivars, for example, of bananas and pumpkins have gone into extinction and the few remaining cultivars have very low yields. In addition, coffee which was once the main cash crop has nearly become non-existent because of low yields. Increased temperatures are also associated with increased incidences of malaria in highland areas that were once free of the disease.

"*We used to grow cassava, coffee, tomatoes, bananas and pumpkins very successfully and without using fertilizers and pesticides. We had bumper harvests but that has changed today because even with heavy investment of inputs, you cannot get a good yield*", farmer from Mbuzii village.

3.3 Sources of and access to weather information

While most of the respondents (67.5%) reported having observed the climatic changes on their own, the radio was the most commonly used media (61%) to access climate and weather information and forecasts (Table 2). Similarly, information on daily, weekly, monthly and seasonal weather forecasts, including climate change and variability were mainly from other sources. These sources included local development organizations and researchers from local institutions who work in the area. Climate and weather information dissemination methods widely used in Lushoto included village meetings (27%) and exchanges with other farmers (24.7%). Use of television, NGOs, researchers, TMA and input suppliers as sources of climate information was very limited. These findings are consistent with those of Lyamchai et al. (2011), who reported that almost 75% of respondents owned a radio in Lushoto, thus making it a useful media for accessing climate information. There is great potential to improve other sources such as NGOs and input suppliers in climate and weather information dissemination.

Table 2. Sources of information on weather forecasts

Source of information on weather forecasts	Percent of respondents
Own observation	67.5
Radio	61
Village meetings	27.8
Neighbours and family	24.7
Newspapers and television	14.3
NGOs and researchers	7.7
Tanzania Meteorology Office	1.3
Input suppliers	1.3
N	77

3.4 Severity and impact of climate related risks

Several extreme events have occurred in Lushoto as summarized in Table 3 due to climate change. Perceived severity of extreme events underlies the ability of a farmer to cope with a hazard they are exposed to. Therefore, the pattern of perceived severity of extreme events is likely to change with increased ability of the farmer to cope with such climate hazards. Table 3 shows the farmers ranking of severity of extreme events. Overall, seasonal drought and crop pests were ranked to be most severe by farmers and had a significant effect on food production. Livestock pests are the least severe climate related risks.

Table 3. Perception of severity of climate related risks

Risks	Percent of respondents (n=77)				
	More severe	Severe	Less severe	Not severe	No response
Seasonal drought	10.4	24.7	49.4	5.2	10.4
Floods	3.9	16.9	6.5	18.2	54.5
Stormy rainfall	7.8	13	31.2	16.9	31.2
Strong wind	5.2	2.6	35.1	16.9	40.3
High temperature	5.2	9.1	50.6	13.0	22.1
Extreme cold	3.9	3.9	23.4	23.4	45.5
Crop pests	14.3	8.2	40.3	11.7	15.6
Livestock pests	0	3.9	29.9	14.3	51.9
Crop diseases	2.6	28.6	39.0	6.5	23.4
Livestock diseases	2.6	11.7	26.0	9.1	50.6
Human disease	5.2	26.0	6.5	14.3	48.1

Most farmers associated crop failure, reduced income, and water scarcity with seasonal drought (Table 4) because their livelihoods depend on rainfed agriculture. The water scarcity was also associated with scarcity of pasture. Rainfall storms had the second greatest negative impact on crops and income. Similarly, the fluctuations in air temperature associated with the seasons had negative impacts on crops and income.

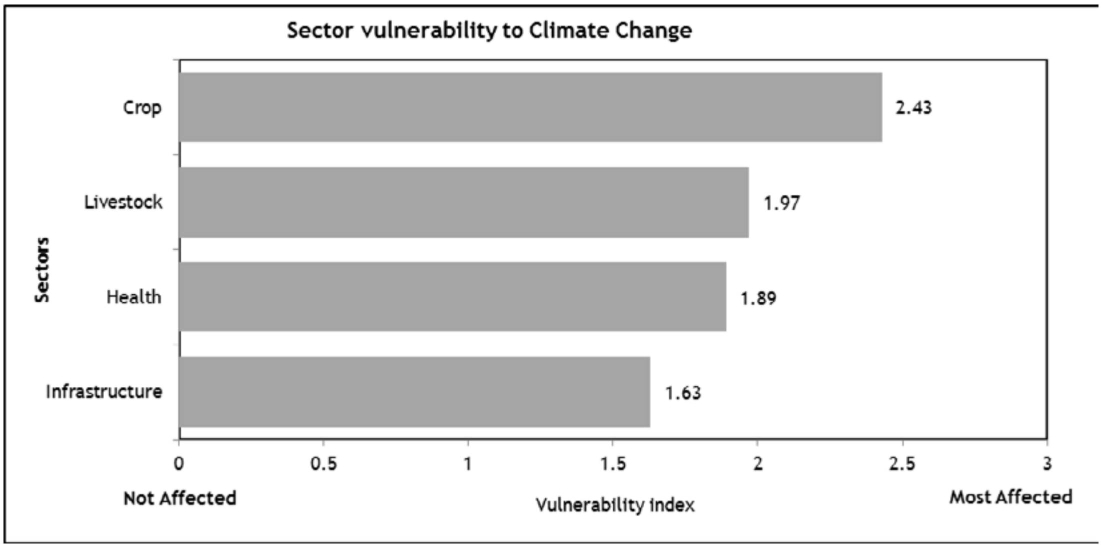
Table 4. Impacts of climate related risks

Impacts	Percent of respondents (n=77)		
	Seasonal drought	Rainfall storms	Change in temperature
Crop failure	97.4	72.7	62.5
Reduced income	93.5	51.9	55.8
Water scarcity	77.9	9.1	32.5
Scarcity of pasture	40.3	11.7	24.7
Outbreak of pests	29.9	13	32.5
Plant diseases	19.5	9.1	14.3
Animal diseases	18.2	10.4	11.7
Destruction of infrastructure	15.6	50.6	5.2
Human diseases	11.7	13	46.8
Death of animals	7.8	2.6	3.9
Land slides	1.3	10.4	1.3
Soil Erosion		48.1	

3.5 Impacts of climate change on various sectors

The effects of climate change and variability differ across various sectors of the economy. A large proportion of farmers reported crop production as the most vulnerable sector to climate change and variability compared to other sectors such as livestock, health and infrastructure (Figure 5). Other sectors were also affected but to a lesser degree.

Figure 5. Farmers' perceptions regarding vulnerability of the different sectors to climate change and variability



Vulnerability index, $V = \frac{1}{n}\sum_{n=1}^{n} s_{ij}$

Where,

n= Sample size

S_i= Sector $_i$ ranking in household $_j$ where the rankings were either **1**, **2** or **3** representing **not affected**, **affected** and **most affected** respectively while $_i$ represent (**crop**, **livestock**, **health** and **infrastructure**) sectors.

3.6 Constraints to crop and livestock production

The reported constraints to crop and livestock production are summarized in Table 5 below. Limited availability of improved seeds and inorganic fertilizer affected crop production. Less than 40% of the respondents reported climate related constraints such as prolonged drought and floods compared to other constraints like weeds and salinization.

Lack of improved breeds, adequate pastures, veterinary drugs and diseases were the core factors affecting livestock production (Table 5). Inadequate extension services cut across both crop and livestock production as most respondents (70%) said they had no contact with extension agents or services.

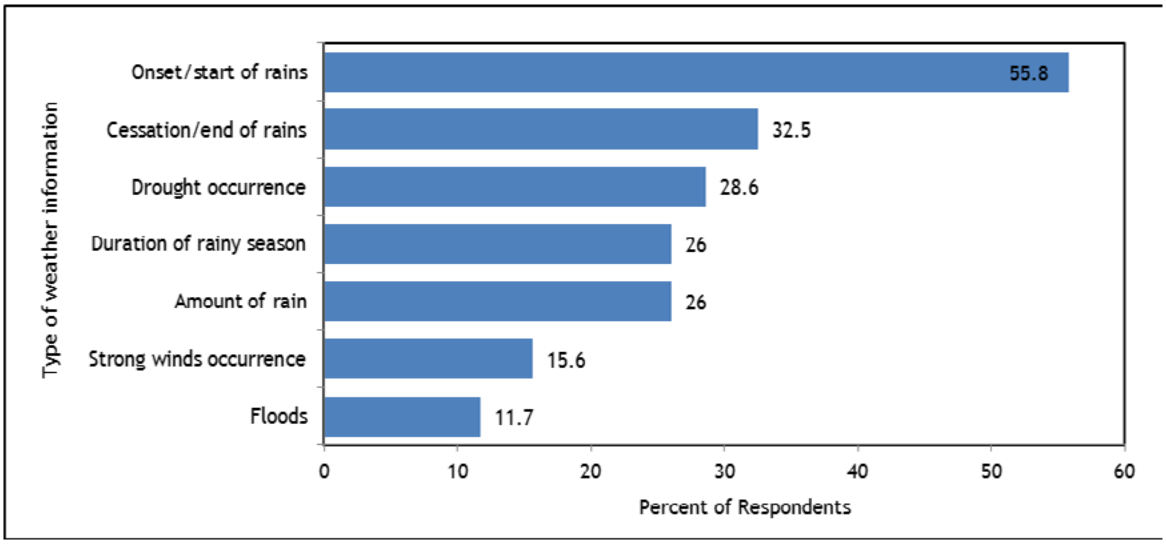
Table 5. Constraints to crop and livestock production

Constraints	Percent of respondents
Lack of improved seeds	94.8
Unavailability or lack of improved breeds	87
Lack of inorganic fertilizer	83.1
Unavailability or lack of pastures	72.7
Inadequate extension services	67.5
Livestock diseases	66.2
Lack of organic fertilizer	54.5
Lack of pesticides	52
Unavailability or lack of veterinary drugs	52
Prolonged drought	37.6
Water scarcity	36.4
Weeds	7.8
Salinization	7.8
Infertility in cattle	7.8
Floods	5.2
N	77

3.7 Community perception of scientific weather forecasts

TMA issues various types of climate information, ranging from daily weather forecasts to seasonal forecasts. About 67% of the respondents had access to weather forecasts, with 56% indicating they were aware of the weather and climate forecasts issued by TMA. More than half (54.5%) of the respondents were using the forecasts in planning their agricultural activities, close to the percentage of those who reported to be aware of the weather and climate forecasts information issued by TMA. The information accessed by the respondents included onset of rainfall, cessation of rainfall, amount of rain, drought occurrence, duration of rainy season, occurrence of strong winds and floods (Figure 6). Seasonal forecasts was the most reliable source of information as reported by 53.2% of the respondents compared to daily forecast (6.5%) and monthly forecast (2.6%).

Figure 6. Type of climate information accessed by respondents

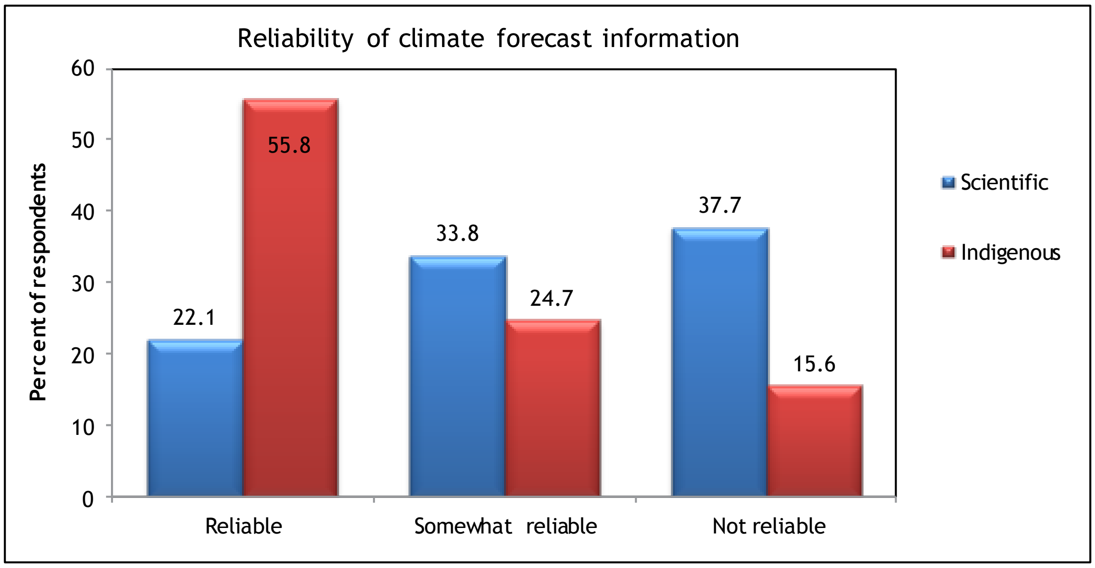


3.8 Indigenous weather forecasts using local indicators

Locally observed variables and experiences have been used to assess and predict the local weather conditions in Lushoto. Indigenous knowledge is often passed on from one generation to the other by the custodians and is not widely documented. A combination of plants, animals, insects, meteorological, and astronomical indicators were commonly used for assessment and prediction (Galacgac and Balisacan 2009, Chang'a et al. 2010, Acharya 2011, Egeru 2012). The most common IK indicators in Lushoto are birds (swallows, hornbills, owls, coucals, and golden orioles), animals (baboons, monkeys, and antelopes), insects (thrips, ants, bees, locusts, and butterflies), shrubs and trees. Over 90% of the respondents indicated that they were aware of the indigenous weather and climate forecasts, with 83% reporting using IK forecasts in planning their agricultural activities.

Figure 7 shows the perceived reliability of the indigenous climate forecasts as compared to the scientific forecasts. Most of the farmers (56%) believed that the IK forecasts were reliable compared to 22% for scientific forecasting. Very few respondents (16%) thought indigenous forecasts were not reliable, as compared to 38% for the scientific forecasts.

Figure 7. Reliability of climate forecast information



Indicators of good rainfall season

Rainfall seasons in Lushoto are divided into three: the short rainy season (October-December), the long rainy season (March-May) and an intermediary season (July-September). The long rainy season is usually more predictable and has clearer indicators which are easy to interpret compared to the short rains.

Local knowledge based on birds

The behaviour, appearance and movement of some birds in Lushoto is frequently used by the local people to predict weather in their communities. The monitoring of the behaviour of the birds is done informally and with time and experience, the local people have come to realize distinct and unique features of some of the birds. The occurrence of large flocks of swallows and swans roaming from the South to the North during the months of September to November, for example. is an indication of onset of short rains. Other birds used as indicators are shown in Table 6.

Table 6. Indigenous knowledge based on birds

Name*	Scientific name	Behaviors related to the rainy season	Percent of respondents (n=77)
Swallows (Vizewe)		Flocks of swallows roaming from South to North in the area are an indication of onset of the *vuli* rains, sometimes within 2 to 3 days the rains start	84.4
Coucal (Dudumizi)	Centropus sp	Dudumizi singing out loud are an indication of *vuli* rains	60
Owl (Bundi)	Nocturnalis strigiformes	An owl in the sky means it is planting season	54.5
Duck (Bata)	Anatidae anseriformes	Ducks stretching their wings and playing in dust is a sign of the onset of rains, especially during the *vuli* season	54.5
Chicken (Kuku)	Gallus gallus	Chicken stretching their wings repeatedly is a sign of onset of *vuli* rains	52
Wild bird (Shemkoko)		Shemkoko singing out loud is an indication of the *vuli* rains	43
Hornbils (Hondohondo)	Buceros bicornis	Flocks of Hondohondo are an indicator of vuli rains	33.7
Fischer's Lovebird (Shundi)	Agapornis fischeri	Shundi crying are an indicator of *vuli* rains	27
Golden oriole (Kurumbizi)		Kurumbizi singing out loud are an indication of a good rainfall season	27
Wild bird (Nyombe)		Nyombe walking to the valley or wetlands indicates *vuli* rains	15.6
Wild bird (Njerunjeru)		Presence of Njerunjeru are an indication of the *masika* rains	15.6

*Local or Kiswahili name in parenthesis

Local knowledge based on large animals

The appearance of wild animals in the village and the behaviour of domestic animals are used by the local communities to predict weather and climate. For example, baboons coming into the village during the dry season indicate a good forthcoming rainy season. Goats, sheep and cattle flapping their ears repeatedly at any time during the dry season is an indication that the rain onset is near and also prospects of a good season (Table 7).

Table 7. Indigenous knowledge based on animals

Name*	Scientific name	Behaviors related to the rainy season	Percent of respondents (n=77)
Baboons (Ngedere), monkeys (Nyani), leopards (Chui) and antelopes (Pofu)	Alouatta caraya-black monkeys, Panthera padus-Leopard, Antilope Cervicapra- antelopes	Appearance of these wild animals in the village is a sign of a good rainfall season ahead	52.0
Sheep (Kondoo)	Ovis aries	Ear flapping by the sheep is an indication of onset and prospects of a good season	48.1
Goat (Mbuzi)	Capra aegagrus hircus	When goats flap their ears, it is an indication of rainfall onset	48.1
Cattle (Ng'ombe)	Bos taurus	Cattle flapping their ears repeatedly is also indicates rainfall onset	48.1

*Local or Kiswahili name in parenthesis

Indicators based on insects

Results from the household interviews and focus group discussions show that various insects are used by the local communities to predict weather and climate. The most commonly used insects were army ants, *Vidododo*, odenteterms, butterflies and frogs (Table 8).

Indicators based on plant phenology

Indigenous indicators based on plant phenology include the flowering of venonia, pears, albizia, and plums. Solanum incunum dropping leaves indicates onset of rains (Table 9).

Table 8. Indigenous knowledge based on insects

Name*	Scientific name	Behavior related to the rainy season	Percent of respondents (n=77)
Army ants (Siafu)	Eciton burchellii, but there are many species	When ants occur in large numbers almost everywhere even inside the houses and appear to be celebrating is an indication of onset of rains and mostly heavy rains during *vuli* (only about a week before onset)	88.3
Insects (Vidododo)		Their presence on Albizia trees with water dripping from them is an indication of a good season (almost one month before rains start (*vuli*)	87
Butterflies (Vipepeo)	Papilio spp. There are a great number of this insects species	Occurrence and migration of butterflies from the south to the north is an indication of early onset of rains and also gives a prospect of a good season. Specifically, black butterflies indicate a prospect of a good season.	80.5
Odenteterms/flying ants (Kumbikumbi)	Reticulitermes spp	Occurrence after strong sunshine indicates proper rains have started, sufficient for planting for *vuli* and *masika* (i.e. the soil has adequate moisture)	70
Grasshoppers (Panzi)	Melanoplus differentialis	Appearance of green grasshoppers in large numbers in the fields indicate the onset of rainfall especially *vuli*	67.5
Frogs/african clawed frog (Vyura)	Xenopus laevis. Various spp	Frogs starting to make a lot of noise is an indication of rainfall onset and the louder the noises become it signifies a good season	46.8
Shelled snails/Garden snail (Kozwe/Konokono)	Helix aspera.	Occurrence of shelled snails in large numbers especially at the time when they are not expected is an indicator of onset of *vuli* season and a prospect of a good season	41.6
Bees (Nyuki)	Apis mellifera	Bees appearing in big groups indicates *masika* rains are about to start	29.9
(Kokoo)		Kokoo carrying eggs indicates *vuli* rains	9.1
Thrips (Vifizi)	Thysanoptera spp	Vifizi insects surrounding wetland areas indicates good rainy season	6.5
Locusts (Nzige)	Spodoptera exigua/ Spodoptera spp	Presence of many armyworms is an indicator of the long rains	2.6
Colobus monkey (Ndega)		Presence of many Colobus Monkeys in the fields	2.6

*Local or Kiswahili name in parenthesis

Table 9. Local knowledge based on plants

Name*	Scientific name	Sign used to relate to the rain	Percent of respondents (n=77)
Datura (Mitura)	Solanumincunum	Abundant fruit production and dropping leaves of the Datura is an indication of rainfall onset. But when they turn upside down it is an indication that the season is going to be too cold and even destructive to crops.	89.6
Albizia (Mishai)	Albizia gummifera	Appearance of insects locally known as vidododo on Albizia tree with water dripping from the trees during a dry season is an indication of the coming of *vuli* rains	74
Pears and plums (Mapea na Mapulamu)	Prunus serotina	Heavy flowering of fruit trees like pears and plums are a good indicator of rainy season	57.0
Pigeon pea (Mbaazi)	Cajanuscajan	If a pigeon pea plant produces a lot of flowers than normal is an indication of a good season	19.5
Venonia (Tugutu)	Vernonia myriantha	When this tree starts to produce flowers it is an indication of early onset of rains	15.6
Baobab/Fig tree (Mkuyu)	Ficus cycomorus	Flowering and generation of new leaves indicates rainfall onset; and prospects of long the rains	7.8
Loquarts (Mafyoksi)	Eryobotrya japonica	Mafyoksi having many flowers is a sign of rain onset and a good season	2.6
Coffee (Kahawa)	Coffea arabica	Flowering of coffee trees is an indication of the *vuli* rains	2.6
Avocado (Vokado)	Percea americana	Avocado trees appearing to have many buds and flowers are an indication of rains	2.6

*Local or Kiswahili name in parenthesis

Indicators based on the moon, sun and wind

The occurrence of halo moon (moon surrounded by a yellow ring) in Lushoto is an indication of onset of rains for both short and long rainy seasons. The North-South wind direction in September is taken as an indicator of onset of short rain season and a sign of heavy rainfall in the upcoming season (Table 10).

Table 10. Moon, sun and wind as local indicators

Sign	Characteristics related to the rainy season	Percent of respondents (n=77)
North-south wind direction in September and in late February	Indicates onset of *vuli* or *masika* season and in most cases a sign of heavy rainfall. Frequent and persistent winds indicate that it will rain within one week. Wind blowing without drying vegetation and soil is also an indication of rains	15.6
Moon surrounded with heavy clouds	A sign of a good rainfall season	14.3
Halo moon (yellowish ring around the moon	An indication of onset for both *vuli* and *masika* seasons	5.2
Slanted position of the moon crescent	An indicator of a bad season especially towards the slanted side	5.2
Moon	Appearance of the moon in a circular shape (normal) is an indication of onset rainfall, while moon with different colors like rainbow indicates onset of *vuli* and *masika* rains	3.9
Wind	Strong winds	2.6
Red moon	Indicates onset of *vuli* rains	2.6
Sun	Sun hitting without wind indicating rains	2.6
White moon	Indicates the onset of rain of *masika* season	2.6

Indicators based on air temperature, clouds and wind

Excessive heat and warming towards the end of the dry season is indicative of good rainfall season. High temperatures during the night are expected to be followed by a rainy day (Table 11).

Table 11. Air temperature and cloud indicators

The sign used to relate to the rain	Percent of respondents (n=77)
High temperatures most of the time indicates that the onset of rains is near	74
High temperature during the night is an indication that it will rain the next day	57
Strong winds and swirl winds indicate imminent rain onset	35.1
White clouds appearing in the evening indicates the prospect of rain the next day	15.6
High humidity and temperature	9.1
Repeated lightning in the evening during the dry season is an indication of onset of *vuli* rains	9.1
Cold wind for about a week is usually followed by rain	1.3
High temperature and blowing wind is an indication of rain	1.3

Other indicators based on human beings

Changes in the human body are at times used to predict weather and climate in Lushoto. Palpitation on top of the right eye and one sided headaches is an indication of onset of rains. Too much heat and humidity also indicate imminent rainfall.

Local indicators of an unreliable rainfall season

Indicators of a bad rainfall season include excessive flowering of mango trees and peaches. Birth trends are also used to predict weather or season, for example, a high birth rate of male children and animals in a particular season is usually taken as a sign of a likely bad season. Also, the moon orientation can be used to predict a bad season, when the moon is inclined towards the horizon, it is believed that there will be less rain on the inclined side.

3.9 IK weather forecasting groups and establishment of weather information flow system at district level

A major output of the study is the formation of three local IK forecasting groups consisting of seven people for each administrative ward. The IK groups meet twice a month to discuss and document the IK weather forecast observations. The groups are required to give two-week weather forecasts twice a month, describing the indicators that they use for forecasts. Apart from issuing new forecasts in their regular meetings, the previous forecast is also reviewed. An example of the forecasts for one of the villages—Yamba village—is presented in Table 12. Overall, the forecasts from the IK groups were fairly accurate as the review showed that most of the time the IK groups got it right. However, it is important to document the IK forecasts to make better conclusions.

Table 12. Example of forecast for Yamba village

Date	Forecast	Indicators	Review
20-12-2011	Enough rainfall was expected	- Occurence of army ants - Shemkoko bird was singing all the time - Ducks were stretching wings and bathing in the dust - Nyange (insects) were making noises	-
31-12-2011	Rainfall expected to decrease	- Strong winds without direction - Cold nights - Vidododo insects are few in trees (mishai) - Army ants are few	The area received enough rainfall as forecasted

At the district level, a core team of weather forecasting experts constituting 29 people was launched at a meeting organized by the District Council. Members of the team included the District Agricultural and Livestock Development Officer (DALDO) as the chairperson, 21 members of IK forecasting teams (seven from each of the three zones), five extension officers from the zones and two members of the project team from SUA and TMA. Specific tasks for the team include:

- Undertaking and recording IK weather forecasts on a 14 day basis, and reporting these to the DALDO and TMA;
- Undertaking and recording scientific weather forecasts by TMA;
- Producing a consensus seasonal weather forecast before and after the season; and
- Disseminating the consensus weather reports to all stakeholders.

4. Conclusion and recommendations

Lack of documentation and reliability are among the key challenges in using IK forecasts. In most cases, IK is sustained from one generation to another through oral history and local expertise, and there is a widening intergenerational gap between the custodians of IK knowledge and the young. There is need for systematic documentation of IK in order to sustain and improve it for use by future generations. The results indicate that IK forecasts were more reliable in the long rainy season (March –May) compared to the short rainy season (October–December) in Lushoto. There is need to strengthen IK in weather forecasting, especially due to increasing changes in weather patterns and variability by integrating it with scientific weather information. One big challenge is that seasonal weather forecasts from the TMA sometimes come later in the season after the IK weather forecasts have already been released in the villages and farmers have already made decisions.

The provision of climate information services in Lushoto will be improved through the district consensus weather forecasting team composed of a multistakeholder partnership that involves the local community, agricultural extension services and the TMA. In order to improve the accuracy of the weather forecasts, there is need for a systematic documentation of IK and establishing a framework for integrating IK and scientific weather forecasting from TMA. Equally important is the establishment of an information dissemination network that provides information to all farmers beyond the three administrative wards, as all the farmers in the district need to manage climate-related risks. This could be achieved by integrating systems for disseminating climate information within the local communities, e.g. through the local schools, community-based organisations, churches in highly religious communities, partnership with NGOs and agricultural input dealers and service providers. Similarly, integration of weather forecasting into the national agricultural policies and District Agricultural Development Programmes (DADPs) would greatly enhance food security, as it would lead to better-informed decisions at farm level. For easier understanding of the forecasts by majority of the farmers, there is need to translate the consensus weather forecasts into the native language. Therefore, there is need to integrate the IK and scientific weather forecasts by having local IK custodians work with TMA officers, in order to produce comprehensive and accurate weather forecasts.

Appendix

Appendix 1: Lushoto IK forecast for the March –May 2012 rainfall for three zones

The long rainfall season in the three zones (upper, middle and lower) of Lushoto will commence in the first week of March, 2012. All the IK indicators show that the rainfall will be normal in the same way it occurs in the good rainfall years within these zones. It will not lead to excessive flooding, and the number of days it is expected to rain will be enough to support crop growth. The rains will neither cease earlier nor later than usual.

Appendix 2: TMA forecast

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PRESS RELEASE

CLIMATE OUTLOOK FOR LUSHOTO IN TANGA REGION,

MARCH – MAY, 2012 RAINFALL SEASON

This statement gives a review of the performance of the October to December (OND), 2011 short rainfall season , the ongoing seasonal rainfall over central, western, southwestern highlands, southern and Southern coast, and an outlook for the March to May (MAM),2012 long rainfall season (*masika*).

A: SUMMARY

The performance of the October to December 2011 short rains (*vuli)* was well over most parts of the country. However, both temporal and spatial distribution was not good in some areas.

Towards the end of the season in December some areas received heavy rainfall that caused catastrophic disasters. The outlook for the March to May, 2012 rainfall season indicates that most parts of the bimodal areas (including Lushoto in Tanga Region) are expected to receive normal to above normal rainfall. These rains are expected to recede towards the end of April, 2012. The principal contributing factors to the observed and predicted weather include enhanced westerly wind flow, anomalous cooling of sea surface temperatures (SSTs) over the central and eastern Atlantic Ocean and slight warming over Southwestern Indian Ocean.

B: RAINFALL PERFORMANCE

The performance of the October to December (OND), 2011 short rains (***vuli)*** was well over most parts of the country. However, both temporal and spatial distribution was not good as some parts of the country received more and heavy rains towards the end of the season. The recorded rainfall amounts in millimeters for some selected stations with their respective percentages of long term means in brackets are indicated below:

BIMODAL AREAS

Northern Coast and hinterlands: Tanga recorded 244.5 mm (280.8%), Pemba 389.2mm (189.5%), Mlingano 557.9mm (336.7%), Handeni 164.4mm (68.9%), Kizimbani 282.7mm (95.8%), Zanzibar 342.0mm (96.4%), Morogoro 83.8mm (110.1%) and JNIA 469.9mm (94.2%) of rainfall.

Northeastern highlands: Moshi recorded 102.4mm (122.8%), Lyamungu 179.2mm (189.2%), Same 66.0mm (65.5%) and KIA 105.5mm (329.7%) of rainfall

It should be noted that: Rainfall amounts below 75% of long term averages are categorized as below normal while those ranging from 75 to 125% are categorized as near normal and those greater than 125% of long term averages are categorized as above normal.

C: CLIMATE SYSTEMS OUTLOOK

This outlook is based on a review of the current and expected state of global climate systems and its likely impacts on the upcoming March to May (MAM), 2012 rainfall seasons in the country. Currently, the Sea Surface Temperatures (SSTs) in the equatorial central Pacific Ocean have been anomalously cooler indicating persistence of weak La Niña conditions. However, slight warming leading to neutral Sea Surface Temperature condition is projected towards the end of MAM, 2012 rainfall season.

The observed and projected cooling over Central equatorial and Eastern Atlantic Ocean coupled with slight warming over the South-western Indian Ocean is expected to contribute and enhance westerly wind towards Tanzania leading to increased rainfall particularly over the western parts. Westerly wave associated with phases of enhanced tropical convection is expected to move across the country during the early period of the season (i.e. March) and thus influencing early rainfall onset. The current weak temperature gradient between western and eastern parts of the Indian Ocean is projected to persist through March, 2012 leading to weak easterlies towards East

African coast. The northern subtropical systems are projected to be relatively weaker than the southern systems that suggest the possibility of fast retreat of the Inter Tropical Convergence Zone (ITCZ) from south to north. Due to projected slight warming over South-western Indian Ocean and due to the likelihood of factors favoring the development of tropical storms, the number of tropical storms is projected to increase and this may have impact on the MAM seasonal rains.

D: SEASONAL RAINFALL OUTLOOK

(i) Long Rainfall Season (*masika*)

The long rainfall season in the northern sector (bimodal areas) of Tanzania is due to commence in the first week of March, 2012. The details are as follows:

Northern coast and hinterlands (Dar es Salaam, Tanga, Coast, northern Morogoro regions and isles of Unguja and Pemba)**:** Rains are expected to start during the first week of March. However, some areas of this region had experienced pre-seasonal rains during the fourth week of February that was associated with tropical storm over the Indian Ocean. The seasonal rains over this region are likely to be normal to above normal.

Northeastern highlands (Kilimanjaro, Arusha and Manyara regions)**:** The onset of rainfall is expected during the first week of March, 2012 and the rains are likely to be Normal to Above Normal

It should be noted that heavy rainfall events are common even in below normal rainfall conditions and periods of longer dry spells may occur even in areas with above normal rainfall. It should also be noted that the March to May rainfall season is more significant for the northern sector of the country.

Tanzania Meteorological Agency will continue to monitor developments of weather systems including ***tropical cyclones over the southwestern Indian Ocean****,* which could influence the rainfall patterns in the country and issue updates as necessary.

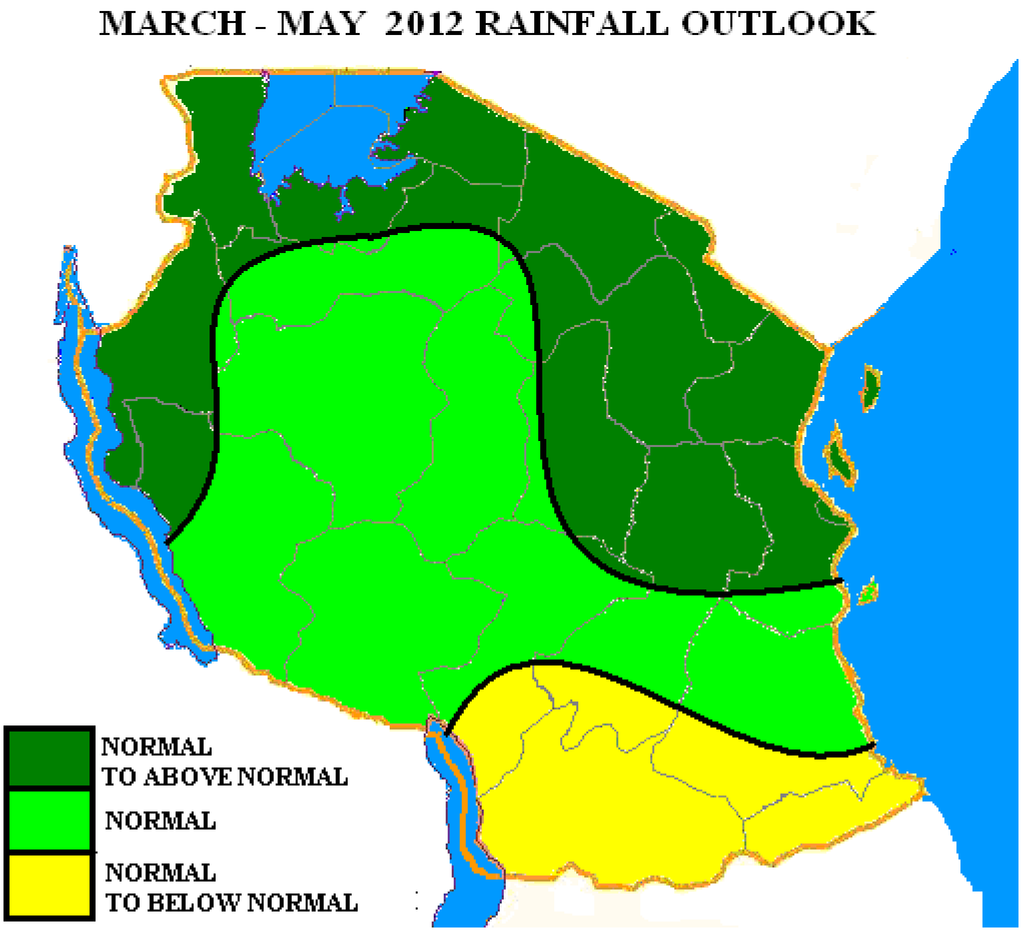

Figure 1: Rainfall Outlook for March to May 2012

E: IMPACTS AND ADVISORY

Agriculture and food Security: Sufficient soil moisture condition is likely over much of the country. The expected above normal rains in bimodal rainfall areas are likely to cause excessive soil moisture levels particularly over lowlands, thus causing water logging of crops. Over northern coast and north eastern highlands, farmers are advised to go for normal *masika* cropping season.

However, farmers are strongly advised to seek more advice from agricultural extension officers.

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