




Utilization of Indigenous Knowledge (IK) Indicators in Weather Forecasting and Livelihood Planning in Coastal Regions of Tanzania

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Abstract

Community members at village level depend on weather information to plan and make decision on livelihood options. The livelihood options and well-being of rural smallholder farmers, pastoralists and fishers in Tanzania are facing ever increasing extreme weather events especially prolonged droughts, temperature rise and floods. This paper investigates traditional indicators which are useful for planning and decision making among farmers, pastoralists and fishers of Lushoto and Pangani in Tanga Region as well as Bagamoyo and Chalinze in Coast Region. Descriptive research method was employed to investigate how traditional indicators are useful for planning during long term (seasonal) and decision making during short term forecasting. Primary data were collected from Indigenous Knowledge (IK) teams, community members and leaders of Local Government Authority. Secondary data were obtained from different sources such as Gray literature, published journals, National Library, District Offices and Regional Officers were the highly consulted sources. Focus Group Discussion, Field Observation, transect walks and Key Informant interviews were the applied methods to systematically document behaviour of local indicators from one month to the next. During Focus Group in each District, elderly farmers, pastoralists and fishers were the sources of primary data. They shared experience on local indicators which they have been observing before the start of the season for the period of 30 years ago. Observation was conducted by IK teams who reported the indicators' behaviour and seasonal events

every after 14 days. Quantitative data were coded to Statistical Package for the Social Sciences version 20 (SPSS 20) tool and analysed using descriptive statistics to show the frequencies of rainfall, showers and drought events which were recorded during IK meetings and those from TMA. Thematic data analysis method integrated hermeneutics approach in analysing data from IK meeting minutes, FGD and KII. Long term forecast indicators successfully informed us on the procedures that lead into determining seasons for either good or poor distribution of rainfall in the next season. Short term traditional indicators were useful for decision making within a season. As long as seasons behave differently from one year to the next, the authors recommend observing indicators for several years and determine how indicators behave when the scientific seasonal outlooks are below normal, normal or above normal.

Keywords

Local Indicators, Indigenous Knowledge, Weather Forecast, Livelihood Planning

1. Introduction

Communities are increasingly facing extreme weather events such as floods, droughts and rising temperature. Extreme weather conditions such as droughts and floods are projected to occur more frequently and become more intense, affecting climate sensitive crops, fisheries and livestock sectors (Alemaw, 2020). Frequent prolonged droughts have significant negative consequences on food security, access to fish resources and reduced livestock productivity associated by high mortality rate.

According to Lymo et al. (2013), one of the impacts of climate change in the agricultural sector in the Kidomole village (Bagamoyo District) include abandonment of cultivation by some villages in favor of exploitation of forest products such as charcoal burning and timber exploitation. It was established that some villagers have been forced to abandon crops like rice due to inadequate water in the previously potential swampy areas. It was also mentioned that maize production has decreased due to inadequate rains. The agricultural calendar has changed, with unreliability of *vuli* which used to occur regularly in September - October. Nyagawa et al. (2020) highly recommended for the Chalinze District to consider having strategies for enhancing observation and monitoring capacity of climate by enhancing observing networks, particularly of rainfall and temperature. In Lushoto district-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 poverty line) and low agricultural productivity (Lyamchai et al., 2011). Amina's conclusion found that more than 63% of farmers of Pangani District were aware of climate change and had heard about it but only 16% of them had access to

weather and climate change information and advice from the local extension officers. The study concluded that the available institution set up and provision of climatic information from mandated institutions to extension services providers to local people as small holder farmers is not straightforward and does not favour small holders in the country.

IPCC's fourth assessment report noted that indigenous knowledge is an invaluable basis for developing adaptation and natural resource management strategies in respect to environment and other forms of change (Parry et al., 2007). This recognition was reaffirmed at the 32nd session of the IPCC in 2010, where it was stated that indigenous knowledge may prove useful for understanding the potential for certain adaptation strategies that are cost-effective, participatory and sustainable. Smallholders across the East Africa region, and particularly in Tanzania, use weather and climate information from indigenous and meteorological sources when making risk-based decisions (Mapfumo et al., 2015). Because of the challenges of applying modern climate knowledge systems, IK is not only relevant but also continues to be the only accessible and affordable alternative source of climatic information among many coastal and rural communities in the East Africa region (Radeny et al., 2019; Chisadza et al., 2015).

Studies comparing indigenous and modern weather and climate forecasting knowledge have found a positive correlation between indicators used by indigenous and modern science (Chisadza et al., 2015; Mahoo et al., 2015; Ngongondo et al., 2021).

These studies inevitably recommend the co-production of weather and climate knowledge by the two knowledge systems (i.e. indigenous and modern) and the creation of a system which synergizes the accuracy of the modern systems as well as the local relevance of the traditional systems (Joshua et al., 2011).

This study was carried out in Chalinze, Bagamoyo, Pangani and Lushoto District Councils in which accessibility to improved weather information is a challenge. The study seeks to:

- 1) Assess the accuracy of indigenous knowledge way of forecasting.
- 2) Assess useful traditional indicators for planning and decision making.
- 3) Propose procedures for integrating indigenous to scientific knowledges of weather forecasting.

This paper will be useful for researchers who wish to explore the usefulness of indigenous knowledge in planning and decision making.

2. Methodology

2.1. Study Areas

This study was conducted in Chalinze, Bagamoyo, Pangani and Lushoto District Councils. Chalinze District Council, specifically Mazizi and Kihangaiko villages were selected due to acute negative impacts of drought among pastoralists. Kidomole village is part of Bagamoyo District which face the same weather extreme like Kihangaiko (see [Figure 1](#)). Farmers in Kidomole village are losing crops es-

pecially during short rain season due to shifting rainfall onset dates. Pangani District, specifically community members of Ushongo and Bweni villages are engaging in fisheries facing weather impact from extreme wind and drought. In Lushoto District, farmers from Mwangoi villages are experiencing shift in rainfall onset dates as well as floods during long rain season.

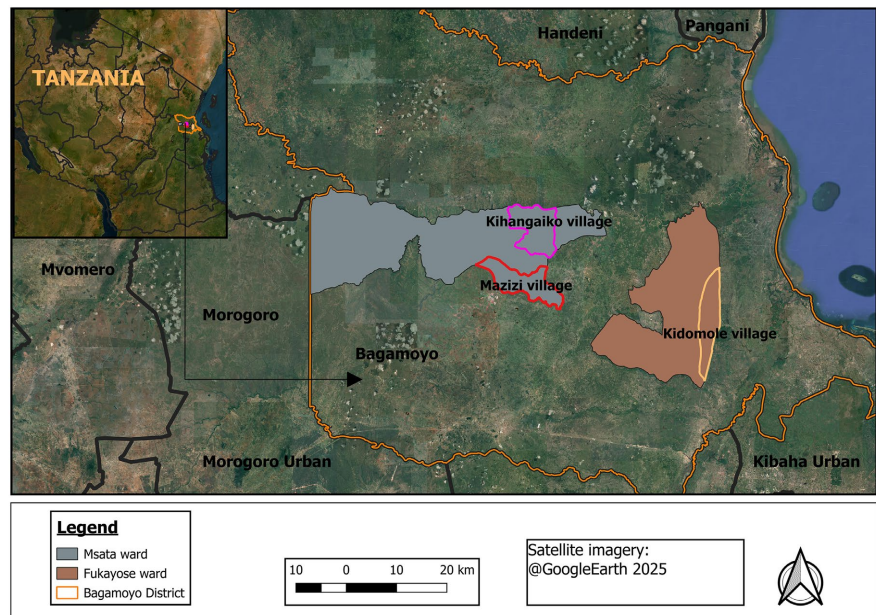


Figure 1. Locations of Mazizi, Kihangaiko and Kidomole villages (Source: Google maps).

Chalinze and Bagamoyo Districts Council share climatic condition and seasonal outlook reports. The rainfall pattern is bimodal with the average rainfall of 260 mm - 330 mm during short rain season (October, November and December) and 490mm - 580 mm during long rainfall (March, April and May) as per seasonal outlook of 2023. Mazizi and Kihangaiko from Msata Ward were selected to observe the existing and utilization of traditional indicators among agro-pastoralists communities while Kidomole from Fukayosi Ward was selected to observe the existing and usefulness of traditional indicators among farmers. Communities practice both crop farming and livestock rearing. The vegetation of Chalinze district is characterised by dominant herbaceous grass species such as *Urochloa*, *Panicum*, and *Eragrostis* species. *Acacia polyacantha*, *Dichrostachys cinerea*, *Acacia tortilis*, *Pterocarpus angolensis* and *Combretum molle* are the dominant woody vegetation (Shemaghinde, 2021). This kind of vegetation and climatic condition favour animal husbandry and farming practices.

Pangani is a coastal district from which two villages of Ushongo and Bweni from Bushiri Ward were selected to observe traditional indicators and their utilization among fishing communities (see **Figure 2**). The climate of Pangani District is characterised by bimodal rainfall in which the average rainfall ranges between 280 mm - 420 mm during short rains (*vuli*) and 490 mm - 650 mm during long

rainy season (*Masika*). Community members of Ushongo village are doing fishing as the main livelihood activity though diversification into farming is practiced to ensure food security. The vegetation around the shores of the Indian ocean is characterised by mangrove forest and little exotic species.

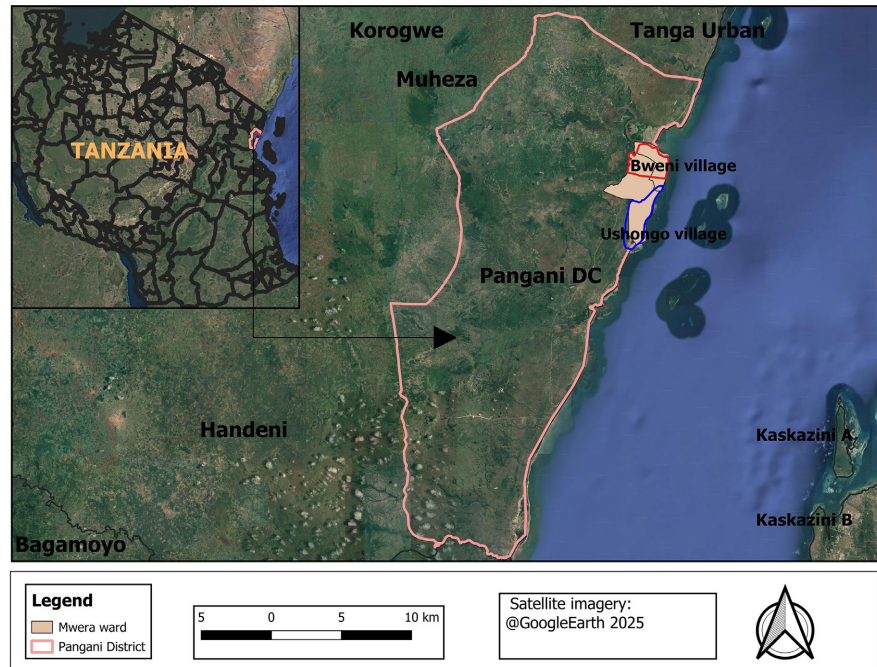


Figure 2. Location of Ushongo, and Bweni villages (Source: Google map).

Lushoto District is characterised by bimodal rainfall pattern with the average rainfall of 280 - 350 mm during short rainy season and 350 - 570 mm during long rainy season (*Masika*). The district has little evaporation rate because it is advantaged with a good altitude of 1400 m above sea level which makes the area cold and therefore little evapotranspiration effect. Mwangoi village was selected from this district to observe the existing and utilization of traditional indicators among community members who practice mixed intensive farming of cereals, vegetables and zero grazing (see **Figure 3**).

2.2. Research Method

Descriptive research method was employed to investigate how rainfall, showers and dry events within a rain season are forecasted during IK meetings at village level. The data collected during IK meetings and those from Tanzania Meteorological Authority were useful in identifying traditional indicators for planning and decision making. Scientific data were used to integrate with IK based weather forecast to compile local specific weather information and climate services.

2.3. Sampling Method

The IK teams at village level were the most important stakeholders for sustainably

documenting traditional indicators after the project phase out. The study used purposeful sampling based on characteristics of age group, sex, living period in a study area, sub village representation and validation by the Village Councils. The age group considered elders (both men and women) who are above 60 years old. Youths, (both males and females) were selected based on the age of 25 - 35. Both elders and youths qualified if they were practicing farming, pastoralism or fisheries. 3 phases of sampling were conducted based on the need.

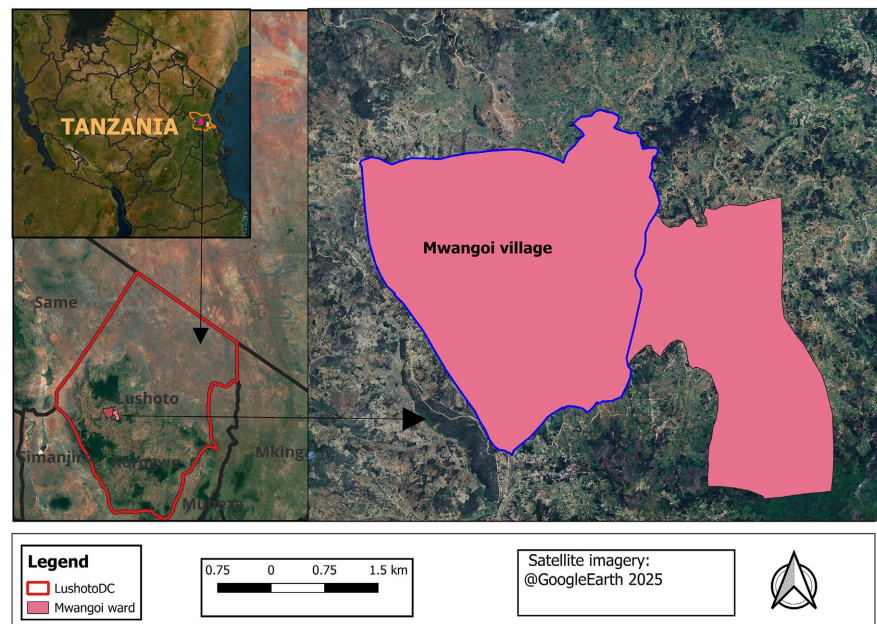


Figure 3. Location of Mwangoi village.

During the first phase of indicators identification, a sample of 24 elders were invited from 6 project villages. Each village was represented by 2 males and 2 females who were mentioned many times during the project baseline survey.

During the second phase of IK team formation at village level, a sample of 11 members per village (66 in total) were proposed to support elders who participated in local indicators identification meeting. This team was trained on how to hold IK meetings, record observed indicators and submit the reports. 12 extension officers who are working at village and ward level of selected areas were identified and trained by researchers to provide technical support during information documentation. The technical support provided by extension officers included: interpretation of decadal and weekly scientific weather forecast during IK meeting. Extension officers were helpful to researchers to explain better about the community's livelihood activities, culture, traditions, education level and technology applications.

During the third phase of impact harvesting, a sample of 66 community representatives (11 from each village) were selected. This category was composed of men, women and youths from project villages to represent farmers, fishers, and pastoralists during Focus Group discussion at the end of the season. Community

members were important at the end of the season because they are end users of weather and climate information provided by Tanzania Meteorological Authority (TMA) and the indigenous knowledge custodians.

In addition to community members, 8 Key Informants were identified at District and Village level to participate in Key Informant Interviews (KII). At District level, the selection criteria were based on people's positions as the head of District Agriculture Livestock and Fisheries Officer (DALFO), officers working under DALFO in sectors of agriculture, fisheries, livestock, cooperatives, irrigation and agricultural statistics. At village level, the selection criteria based on people's positions like Village Executive Officer or Village Chairperson. The KII collected data to determine leaders' opinions on sustainability of IK teams to strengthen bottom-up ways of weather information dissemination.

2.4. Data Collection

Both primary and secondary data were collected during this study. Primary data were collected from IK groups, community members during FGD and Informants during KII. Other primary data were the rainfall records collected from Tanzania Meteorological Authority (TMA) to trace the performance of short rain season.

Phase I of data collection

During the first phase, traditional indicators were identified during the meeting with 24 elders from 6 villages. It was the initial stage of mapping indicators and observing differences or similarities among selected villages. It was a preparatory stage before the observation stage in each village. Traditional indicators were recorded in **Table 1** per village to show their behaviour in relation to season changes.

Table 1. Description of traditional indicators for short term forecast.

Village	Traditional name	Description of traditional indicator
Mazizi	<i>Ufakule</i>	Small ants which signified the approach of rains season when they appear on ground surface. It is believed that <i>ufakule</i> were escaping high temperature which forms underground few days before the start of rain season. They were observed in mid-August for the first time in Mazizi village, but their appearance was again named by neighbouring village of Kihangaiko as Sukumvi
	<i>Msoso, Msiga, Mkole</i>	A tree species which were referred to forecast showers in next few days
	<i>Sukumvi</i>	Small red ants which stayed in groups (Unlike big ants which move in caravan). This is a sma as <i>ufakule</i> ants of Mazizi village
Kihangaiko	<i>Kipoi, vyokoe & Mwanadeka</i>	Bird species which were referred to forecast rain in next 3 - 4 weeks
	<i>Ngatiko</i>	Clouds in gravel-like appearance structure. Used to predict off season rainfall in August.
	<i>Ng'ori</i>	Bird specie referred to forecast the rainfall event in a season upon its appearance. Its appearance and behaviour was observed in December.
Kidomole	<i>Kambomtera & Mumbi</i>	Bird species which were referred to forecast rainfall in next less than 3 weeks upon their appearance in September.
	<i>Mwangaa, Mlamilamwani & Mfureta</i>	Tree species which were referred to during weather forecasting especially when they flowered in September.

Continued

	<i>Chago</i>	Crabs which was referred to forecast rainfall when they moved from underground habitat and change color into deep brown in September to signify the approach of rain season.
Ushongo and Bweni	<i>Vitwitwi</i>	Bird species appearance in September which were referred to forecast rain in next 3 - 4 weeks
	<i>Njenje</i>	A bird species with a unique sound which was observed in October to predict rainfall in less than 10 days ahead
Mwangoi	<i>Shemkoko</i>	A bird species with a unique sound which was observed in October to predict rainfall in less than 10 days ahead

Phase II of data collection

During the second phase, observation method was applied to describe the behaviour of traditional indicators and forecast the probable weather changes in the next 15 days. The meetings of IK teams started between June and September before the start of short rain season. IK teams held the meetings every 15th and 30th of every month. Each team member was required to collect information from neighbours in a particular sub village concerning observed traditional indicators, challenges facing livelihood performance and experience of solving challenges by local means. The meeting minutes compiled the names of participants according to their gender and sub villages which they represented, sex, contacts and signatures. Their agenda included assessment of weather performance during the last 15 days and assessing the progress of livelihoods. The contents included records of rainfall events though in qualitative terms. It was agreed to clarify season performance as “*rain event*” if people could stop walking or running to safe shelters; “*showers event*” if people could still walk around and work; “*dry periods*” if there was no rain or showers. They mentioned the dates in which all events happened for future frequency analysis. This was a moment to assess the accuracy of the last forecast if they were *accurate*, *almost accurate* or *not accurate*. The next agenda required to fill a table of indicators and tell the behaviour could be related to weather performance in the next 15 days. The last agenda was packaging of advisory which was compiled and disseminated to end users of weather information. The meetings were headed by chairperson elected by IK teams while extension workers facilitated information sharing to heads of Agriculture, livestock and fisheries at District level. The approach of tasking IK teams at observation stage was designed to prepare the sustainability plan after the end of the study.

While IK teams were collecting qualitative data and their frequencies, researchers were collecting quantitative data from TMA on season performance in terms of rainfall amount. Researchers were constantly communicating with IK teams to streamline the forecast especially when several traditional indicators were recorded to forecast the weather performance in the next 15 days.

Phase III of data collection

During this stage, the team of researchers went to community members for impact harvesting. Focus Group Discussion (FGD) with 11 participants was held using guiding questions. The data collected were used to understand the community

perception on reliability of traditional indicators for planning their livelihood before the start of rain season. Key Informant Interviews (KII) were conducted to collect qualitative data from the village officers and district officers from the division of agriculture, livestock and fisheries. The approach is similar to Gbangou et al. (2021) who documented various traditional indicators through Focus Group Discussion (FGD) and in-depth interviews with smallholder farmers in Ada, southern Ghana in the Volta Delta.

2.5. Data Analysis

Quantitative data were coded to Statistical Package for the Social Sciences version 20 (SPSS 20) tool and analysed using descriptive statistics to show the frequencies of rainfall, showers and drought events which were recorded during IK meetings and those from TMA.

Thematic data analysis method integrated hermeneutics approach in analysing data from IK meeting minutes, FGD and KII. Drummond et al. (2004) described the meaning of hermeneutics as the Greek word which means to express, explain, translate or interpret a message. The approach therefore was used to describe the accuracy of the traditional way of weather forecast and usefulness of traditional indicators for planning and decision making. Guye et al. (2022) analysed primary data from FGD by using hermeneutics approach for contextualizing how pastoralists use indigenous weather forecasting and weather events monitoring for pastoral resilience.

3. Results

3.1. Observed Traditional Indicators during IK Based Weather Forecast

Insects, birds, clouds, fog, dew, temperature levels, wind direction, plants, stars and fish are the common traditional indicators which were observed (see Figure 4). Birds, plants and insects show high percentage of appearance because they are used by all communities of farmers, pastoralists and fishers and their behaviour is relevant during the rainy seasons.

Table 1 describe local indicators which forecasters adopted in form of traditional names. They are categorised as short-term indicators because their behaviours appeared more than once in a season to inform the rainfall event few days ahead.

The indicators which are named in Kiswahili or English are not listed in Table 1, but they were observed and referred to during planning and decision for livelihood options. From Lushoto District, Mwangoi village and other adjacent villages like Dule, the unique indicator that was observed is the parasitic relationship between insects and plants. Aphids, locally known as “*kidododo*” or “*vitema mate*” feed a tree species locally known as “*mshai*” tree. They actively feed on barks of the host tree before the start of the short rain season. They form colonies on tree barks with high concentration on young branches (see Figure 5). The process of hatching was

not discovered but colonies formation, stages of maturity and feeding on tree barks were observed for 7 days. Feeding on barks form scars which induce reaction of the host tree to produce water-like fluids dropping on ground. This phenomenon means the beginning of the rainy season among the local communities of *Wasambaa* tribe who are living in Mwangoi village and adjacent villages.

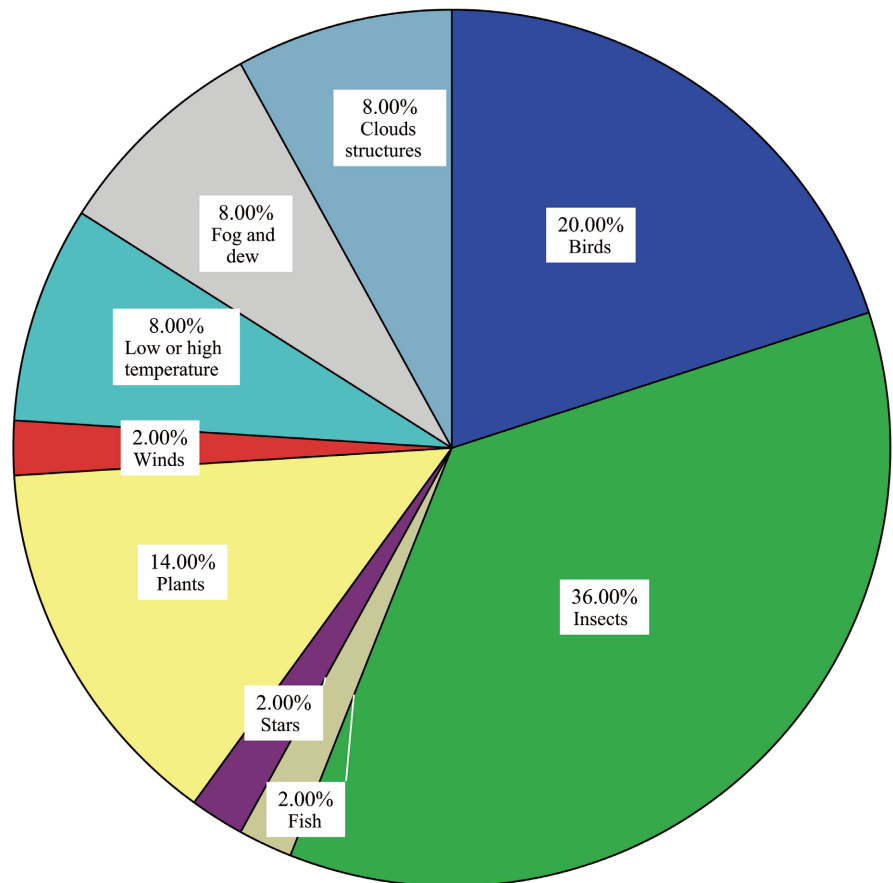


Figure 4. Categories of traditional indicators.



Figure 5. Parasitic relationship between insects and plant species.

Table 2 describes traditional indicators which are unique for describing the nature of the season, either good or bad in terms of rainfall amount and distribution. Unlike short term indicators, long term indicators appear once before the season in which community members communicate to each other to apply the information in planning their livelihood.

Table 2. Traditional indicators for seasonal (long term) forecast.

Village	Unique traditional name	Indicator's behaviour and interpretation
Ushongo and Bweni	<i>Mchoo</i>	Off season rains which rain after <i>matila</i> winds. They were associated with flowering of Mango to determine or above normal rainfall during the short rain season of October-December. If mchoo rains every after one week, it stimulates flowering and fruiting of mangoes but it reduces the expected amount and of short season rainfall and vice versa. That is why some communities believe in poor season performance when mango trees bear too much fruits.
Kihangaiko	<i>Chiwasege</i>	Wind movement from North to South in September to imply below normal rainfall.

Pastoralist communities in Mazizi, Kihangaiko and Msaraza villages described the positioning of the new moon in relation to weather forecast (See **Figure 6**). When the moon is at its smallest shape (new moon) and the left end point is down, it is literally translated that God is fetching water, then there are rains in that particular month. When the right side of the moon is down then there is no rain, literally translated that the bowl of God has no water.

After the end of long rain season in May 2023, data collection through observation confirmed the positioning of the new moon with all end points facing upwards in June. It was signifying dry weather conditions until July. No rainfall was reported during the month of June. In July 2023, the new moon appeared with right-way tilt signifying rainfall in some Districts. IK meeting minutes reported showers in Kihangaiko village during the third week of July. During that period, the waxing moon changed position by tilting left way. This is the same position which appeared during the new moon in August, September, October and November though the angle of tilt was different. In November, the new moon appeared on November 2, 2024 with position signified that “*God is fetching water*”. On the 5th day after the new moon, the position changed with the right end point going down signifying that “*God is pouring water*”. The meeting minutes from IK groups showed that it rained on November 6 and 5, 2024 in Msaraza and Mazizi respectively.

3.2. Accuracy of Indigenous Knowledge Way of Weather Forecast

Figure 7 shows the trends of accuracy which were documented during the IK meetings at village level. The forecast performance was rated *accurate* if it

matched correctly with weather performance during the last 15 days otherwise

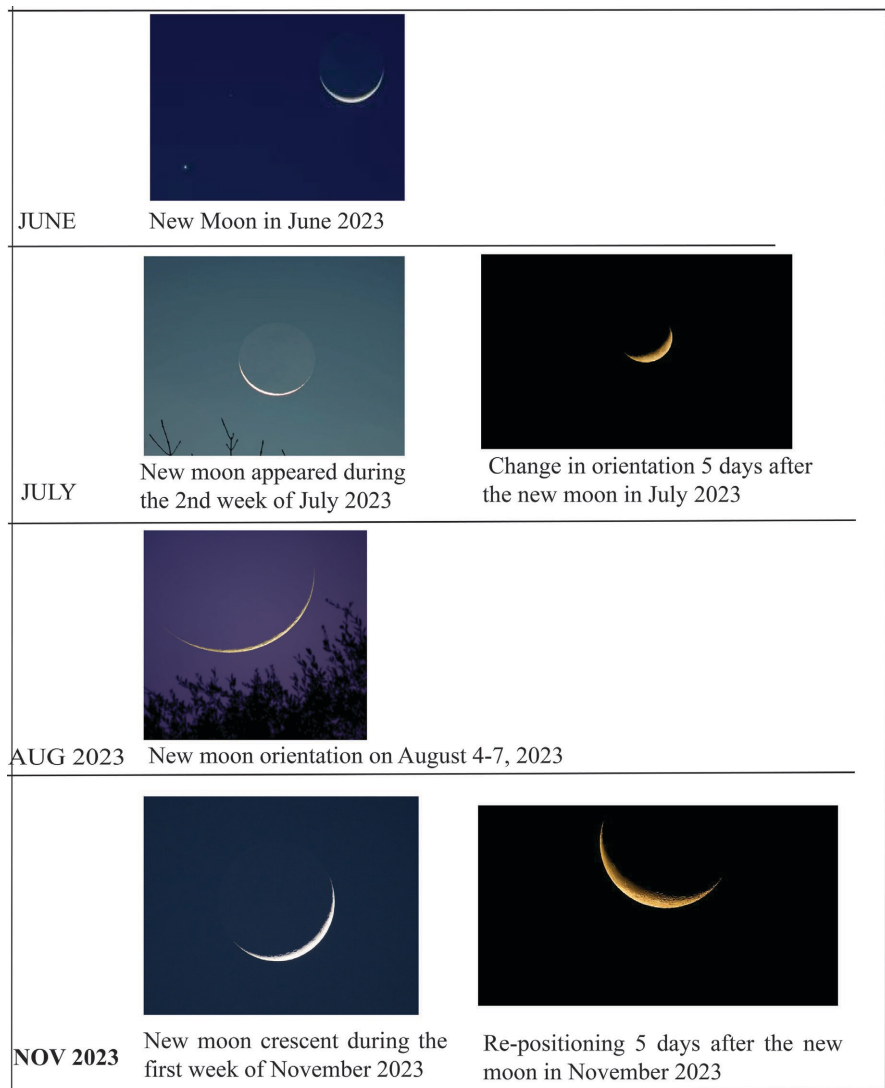


Figure 6. Monthly rainfall forecast with reference to new moon crescent 2023.

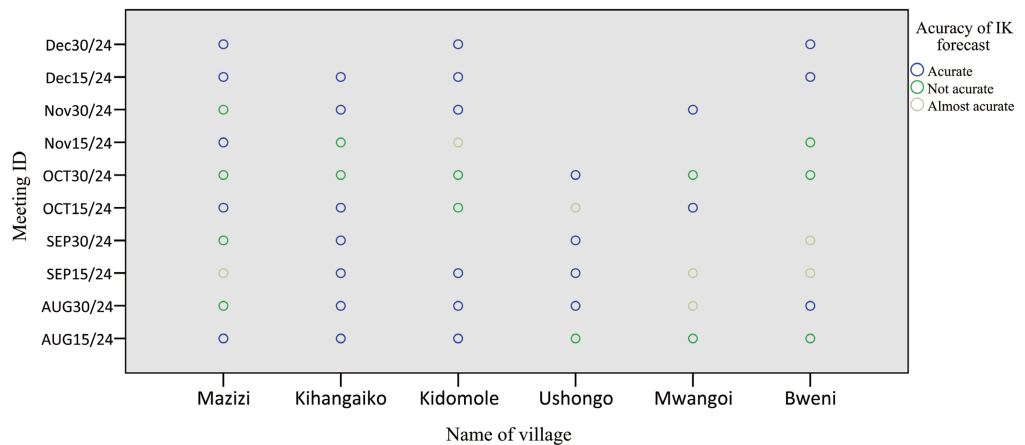


Figure 7. Forecast accuracy with traditional indicators.

the rating was *not accurate*. The *almost accurate* rate was marked if rainfall was forecasted but showers rained instead. This approach was applied for short term forecast after the start of the season. Traditional indicators which were referred to define the long term (seasonal outlook) are discussed in the integration section.

3.3. Local Standards of Seasonal Performance at Village Level

The local approach of describing the amount of rainfall may not meet the normal standards but community members have the common understanding. They use terms like “*enough rainfall*”, “*showers*” or “*it is shining*” to imply normal to above normal, below normal and no rain. The results for Kidomole and Mazizi villages have been referred to as samples presentations and part of discussion.

The sampled data which were recorded and analysed as seasonal performance in Mazizi (Msata Ward) and Kidomole (Fukayosi Ward) between August and December 2024 are presented in **Figure 8** and **Figure 9** below.

3.4. Scientific Results of Seasonal Performance in Project Areas

Figures 10-12 are the description of scientific data which were recorded by TMA while tracing the season performance of Bagamoyo District.

4. Discussion

4.1. Utilization of Traditional Indicators for Planning Livelihood Activities

When it comes to weather forecasting for small-scale rainfed agriculture, contextualizing timescale is a paramount aspect that must be considered (Nyadzi et al., 2022). Medium to long term forecasts covering timescales of weeks or months are also important for planning purposes, such as deciding which crops to plant

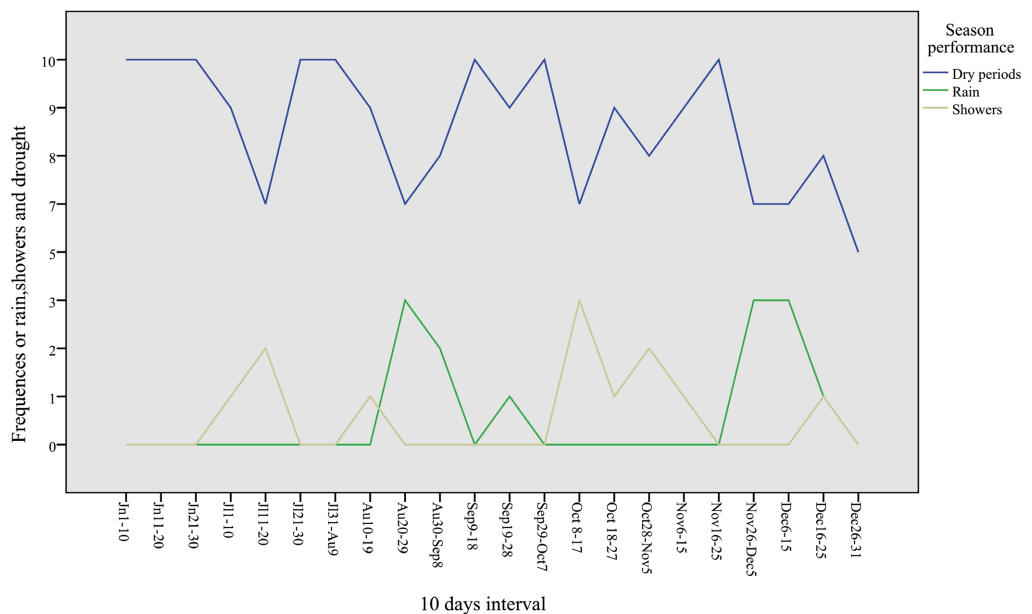


Figure 8. Trend of seasonal performance based on traditional records Mazizi village.

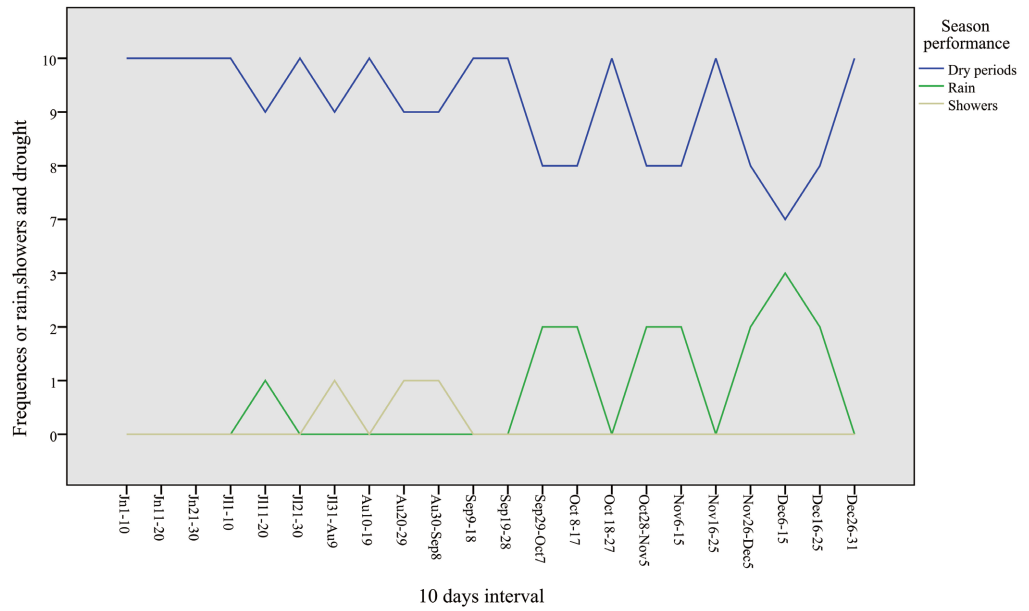


Figure 9. Trend of seasonal performance based on traditional data in Kidomole village.

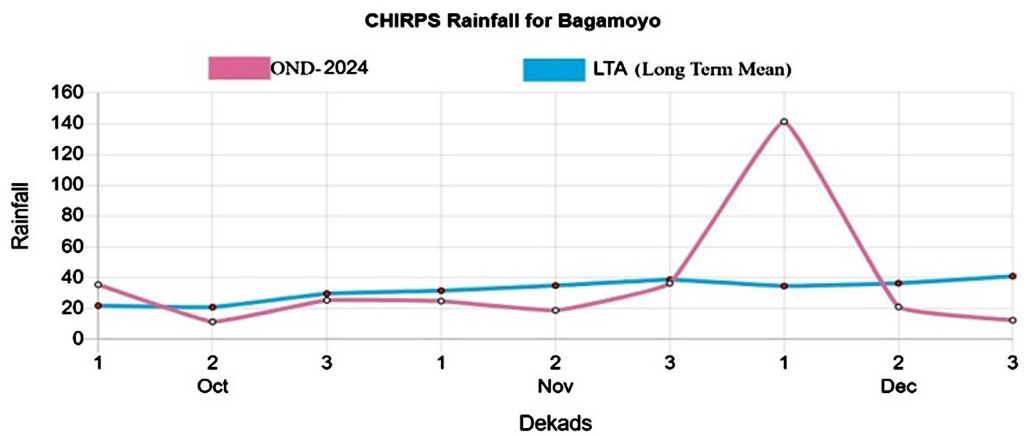


Figure 10. Trend of seasonal performance based on scientific data in Bagamoyo District.

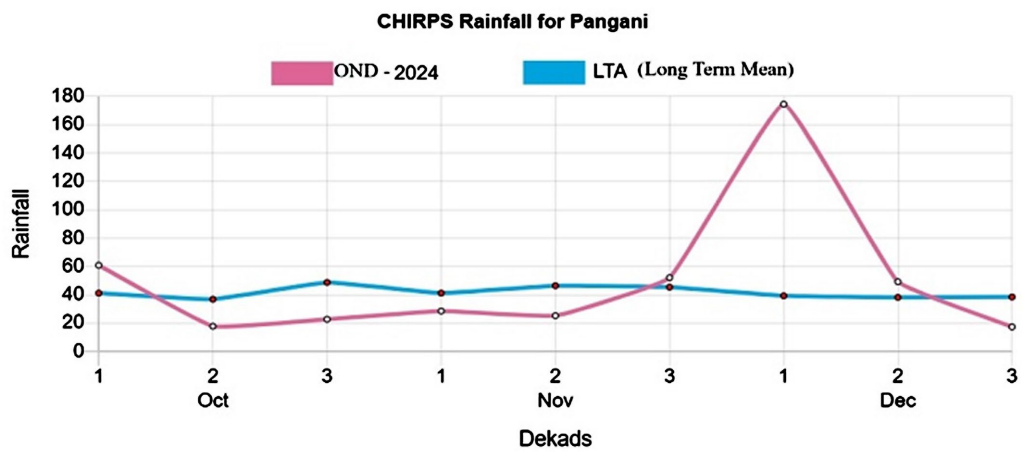


Figure 11. Trend of seasonal performance based on scientific data in Pangani District.

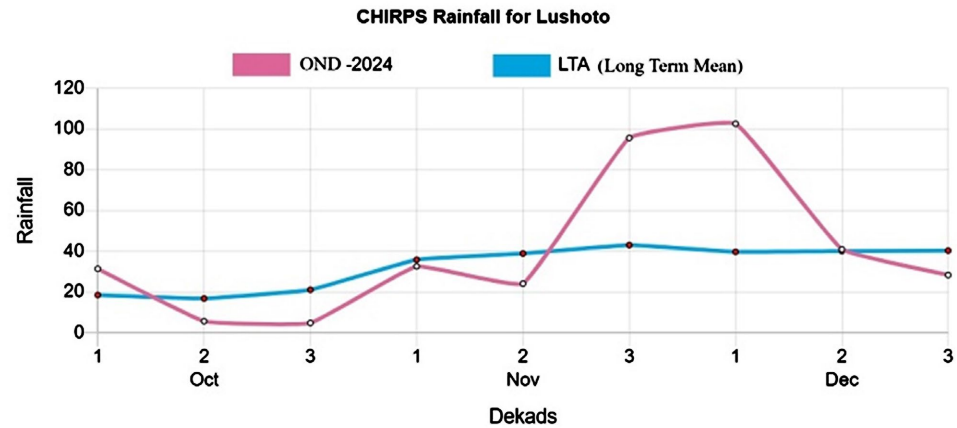


Figure 12. Trend of seasonal performance based on scientific data in Lushoto District.

in a given season or when to make investments in equipment or infrastructure (Paparrizos et al., 2023). Community members from Mazizi, Kihangaiko and Kidomole predict the next seasonal outlook by interpreting *wind movement between South and North in September*. The wind moved from South to North in an abnormal direction, traditionally known as *chiwasange*, traditionally interpreted as the indicator for below normal rainfall. Similar indicator for long term forecast is the offseason rain events, locally known as *mchoo* showers which happens between July and September in Ushongo village. Elders interpret the repeated *mchoo* showers as the event of *reducing the pending rainfall share*. *Mchoo* showers support mango flowers to pollinate and make more mangoes which was another traditional indicator of a *bad future* of the next season. Continuous tracing such traditional indicator may be useful integrating IK in local government plans while addressing the challenges of food availability and food security. The indicator is useful for community members to design technologies that promote climate smart agriculture during hardship periods. Joshua et al. (2011) observed the similar phenomenon in Malawi whereby Heavy flowering of the mango trees indicate a potential drought season.

4.2. Utilization of Traditional Indicators for Decision Making

Smallholders undertake their farm decisions based on indigenous or local practices e.g., using certain local environmental indicators, traditional calendars and beliefs (Chand et al., 2014; Kumar et al., 2020). Most of farmers observed the sequence of events when ants were making homes, protecting the queen closely, collecting food and closing the tops of their homes (see Figure 13).

The last event of closing the homes is traditionally interpreted as the beginning of breeding stage make new colonies during the rainy season. Farmers integrate the sequences of activities among ants family with other seasonal forecasting indicators as well as scientific seasonal outlook to make decisions on the planting week. Mapfumo et al. (2015) cited the similar cases from the farmers of Zimbabwe who made decisions after tracing changes for five years rainfall seasons which

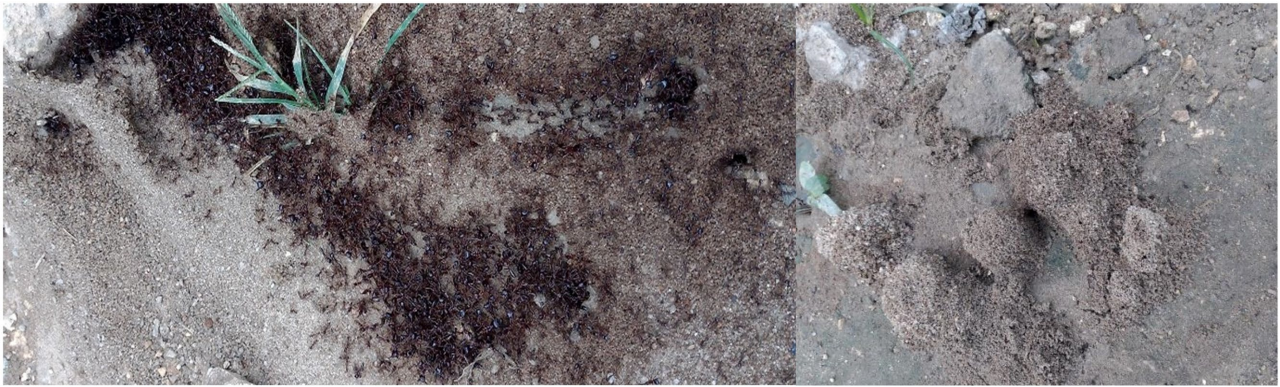


Figure 13. Red ants characteristics before the start of short rain season in Kidomole Village.

indicated step by step stages such as onset of winter season in May, rains coming in August after harvesting and processing grains, the end of wildfire in September, sprouting of new tree leaves and marking the beginning of rain season in October.

Pastoralists decide to shift from wetlands towards well draining soils by referring to the orientation of the new moon. It is normal for the crescent to change the original orientation either from left orientation to right orientation or vice versa within the same circle. It may be a challenge to trace the sequence of moon orientation until the raining date but pastoralists in Kihangaiko village are sure of having rainfall when the end points of the moon were orienting by right. Some literature show the same experience but they refer to the West and East orientation of the new moon. [Mugi-Ngenga et al. \(2021\)](#) observed the moon behaviour in Tharaka, South Kenya, that when the moon is slightly tilted to the west and the crescent is facing downward during the months of September and October, there is imminent rainfall and farmers can plant.

4.3. Integrating IK and Scientific Based Weather Forecast for Planning Livelihood

Essentially, indigenous forecasting is not solely based on personal experience but also on trend analysis ([Kolawole et al., 2014](#)). The trends for the last three years show that Tanzania Meteorological Authority published scientific seasonal outlook on September 2, 2022, August 24, 2023 and August 22, 2024. On the other hand, IK trend analysis shows that behavioural changes in traditional indicators can be traced from July to September before the publication of scientific seasonal outlook. The right period for integration is therefore the first-second week of September. The procedure is useful because all events of forecast and integration happen before the normal dates of rainfall onset, that is October. Integration is valid if the event is attended by different stakeholders from the district office, development partners, National Meteorological Officers, extension workers and representatives from end users. The integration is perfect if stakeholders compare the events of systematically documented long term traditional indicators with scientific seasonal outlook. It makes more sense if the meteorologists support IK stakeholders by explaining the scientific reason for why long term traditional indicators

change behaviours from one specific period of time to the other. It gives confidence to the IK teams when their findings are recognized and described scientifically. It is wise to utilize this opportunity to package services which aid farmers, pastoralists and fishers to plan important livelihoods which look like integrated weather forecast.

4.4. Sustainability of Indigenous Knowledge (IK) Teams at Village Level

The researcher realized that participants of IK meetings were active from August to December with a good number of sub villages represented. There are incidents in which information was not submitted on time due to lack of smartphones. Some villages did not hold the meetings on agreed date due to events which affect the whole community, including funerals, weather calamities or engagements in livelihood management. The study finds sustainability of IK teams if they will be given time during social gathering to promote weather information dissemination while getting financial and capacity building support from the district departments.

This study has documented indicators through collection of qualitative information and periodic observation of indicator behaviours during the dry and rainy seasons. Voluntary participation of community members in IK meetings may be the hindering factor if there is no external support to influence documentation of traditional indicators. Researchers need the information, but community members have to make life through livelihood activities. The processes of IK based forecast will be trusted and sustainable if adopted in Local Government Authority structures and planning.

5. Conclusion

Despite having scientific and IK based forecast which described the seasonal outlook as bellow normal to normal, there are few farmers who planted crops from September to October by relying on the moon which was surrounded by a reddish ring in Mazizi village. Some indicators like plant species of *mfureta* and *miombo* were previously the references in villages of Bagamoyo District but community members have lost trust because climate change has induced misbehaving of the indicators. Radeny et al. (2019) also noted that scientists claim that local weather and climate forecast knowledge has decreased its trust due to the loss of indicators as a result of climate change. Other farmers in Chalinze district relied on business as usual by planting in dust expecting seeds to germinate whenever the season onset starts. Such a decision which does not consider time scale systematic observation of traditional indicators is risky and the main reason for farmers to face economic loss during early onset with prolonged dry spells. Mwongera et al. (2014) observed similar risks associated with planting during the first rain without taking caution of dry spells after the first rains. It is evident that relying on one source of weather information is risky.

The utilization of indigenous knowledge for planning and decision-making shows to be reliable but the translation of indicators' behaviour has not reached the accuracy of telling the exact dates of the month for the event to occur. We cannot therefore depend on one kind of weather forecast for decision making during this time of climate change scenarios. Though most indicators are commonly shared from one village to another, environmental degradation especially struggle for land ownership, inappropriate usage of agricultural inputs, illegal fishing practices and overgrazing are some of the factors that are slowly pushing away the availability, accessibility and sustainability of such indicators. It is therefore recommended for the government of Tanzania to emphasize the implementation of policies which promote environmental and biodiversity protection such as climate smart agriculture and application of community-based adaptation techniques. However, population increase. Documentation for heritage to the upcoming young generation and promotion of the good social events, cultural practices, rituals and celebrations which embrace environmental conservation of nature are recommended as the most effective approaches than law enforcement.

6. Recommendation

Authors recommend for Local Government Authorities to design programs for stories telling between aged people and the youths for consistent transmission of the IK education from one generation to another. Thanks to the Maasai pastoral communities who promote the knowledge through traditional/cultural ceremonies.

As scientific weather forecast makes conclusion based on different factors, IK based weather forecasting reports should be trusted if the findings they will be concluded based on documentation of several indicators and their behaviour. Relying on few traditional indicators may mislead the forecast if interpreters are not well informed of the behaviour.

The World Meteorological Organization (WMO) has done much on scientific weather forecast standards which ensures uniformity all over the world. More efforts are important in standardizing procedures for IK based forecast. This paper may be a source of new findings while standardizing the procedures for meetings, number of indicators for reference, duration of data collection, involving community members at each stage of data collection and informing the beneficiaries about the new findings.

Livelihood activities which depend on rainfall are at risk if the season performs poorly. It is recommended for the departments of agriculture, livestock and fisheries to strengthen dissemination approaches of weather information and climate services. The approaches should integrate digital technology, extension workers' roles and raise the voice of indigenous teams to hold discussion on challenges that are anticipated and the opportunities which are available to benefit from the use of weather information.

The final recommendation is for researchers to apply the methodology in this

paper to conduct observations in other villages where the project could not reach. The same methodology and approaches may be applied for several years in the same villages of our project area to fill the gaps and inform the same community about the potential of Indigenous Knowledge for better planning and decision making.

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Conflicts of Interest

The authors declare no conflict of interest regarding the publication of this paper.

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