Journal of Geography and Regional Planning Vol. 3(4), pp. 66-72, April 2010
Available online at http://www.academicjournals.org/JGRP
ISSN 2070-1845© 2010 Academic Journals

Full Length Research Paper

Indigenous knowledge in seasonal rainfall prediction in Tanzania: A case of the South-western Highland of Tanzania

Ladislaus B. Chang'a[1,2]*, Pius Z. Yanda[2] and James Ngana[2]

[1]Tanzania Meteorological Agency, Dar es Salaam, Tanzania.
[2]Institute of Resource Assessment, University of Dar es Salaam, Tanzania.

Accepted 1 March, 2010

This paper describes how farmers in the South-western Highland of Tanzania predict rainfall using local environmental indicators and astronomical factors. The perceptions of the local communities on conventional weather and climate forecasts were also assessed. The study was conducted in Rungwe and Kilolo districts in Mbeya and Iringa regions respectively. Participatory rural appraisal methods, key informant interviews and focus group discussions were used in data collection and the collected data was analyzed using Statistical package for social science. It has been found that plant phenology is widely used by local communities in both districts in seasonal rainfall forecasting. Early and significant flowering of Mihemi (*Erythrina abyssinica*) and Mikwe (*Brachystegia speciformis*) trees from July to November has been identified to be one of the signals of good rainfall season. The behaviour of Dudumizi bird has been singled out as one of the best indicator for rainfall. Both Indigenous Knowledge specialists and TMA experts have predicted 2009/2010 rainfall season to feature normal to above normal rainfall. Systematic documentation and subsequent integration of indigenous knowledge into conventional weather forecasting system is recommended as one of the strategy that could help to improve the accuracy of seasonal rainfall forecasts under a changing climate.

Key words: Climate variability, seasonal forecasting, El Nino, Dudumizi, indigenous knowledge.

INTRODUCTION

Observed increase in climate variability in most East African countries and particularly in Tanzania has increased the uncertainty in seasonal rainfall prediction and poses a greater challenge to scientists in their efforts to improve forecast accuracy and reliability. Pertinent action are therefore needed to address these challenges to enable the agricultural sector to significantly contribute in the attainment of Tanzania development Vision (VISION, 2025) and achievement of newly launched agricultural policy under the theme "Kilimo kwanza". The newly launched "Kilimo kwanza" initiative put agricultural sector as the number one priority in all development activities in Tanzania, with the purpose of enhancing agricultural productivity and improved quality in agricultural produce through the use of good and modern agronomic practices. However, since agriculture activities in Tanzania are mainly rain fed, productivity of crops to large extent depend on the appropriate and effective decision on when , where and what to plant, which in turn will depend much on the accuracy and reliability of seasonal rainfall forecasting. Officially, Tanzania Meteorological Agency (TMA) is the Agency responsible for monitoring and predicting weather and climate in Tanzania, including seasonal rainfall forecasting. Conventional weather and climate prediction is normally done using statistical and dynamical methods (Johnston et al., 2004; Gissila et al., 2004). In spite of the slight improvement in forecasting accuracy, the present forecasting accuracy, which is 75%, is still not sufficient and the challenges are still numerous due to the strong spatial and temporal variability nature of rainfall

*Corresponding author. E-mail: changa60@hotmail.com, changa@meteo.go.tz.

Abbreviations: IK, Indigenous knowledge; **TMA,** Tanzania meteorological agency; **SWH,** South Western highland.

(Ogallo, 1989; Nyenzi et al., 1999; Zorita and Tilya, 2002). Recent climate change projection indicates increased climate variability in the context of climate change over most part of the world (IPCC, 2007). It is therefore imperative that efforts to improve accuracy and reliability of seasonal forecast will need to be enhanced. Systematic documentation and subsequently integration of Indigenous Knowledge (IK) in seasonal rainfall forecasting is one of the promising initiatives that need to be explored.

Historically and to date traditional local communities in different part of the world have continued to rely on IK to conserve the environment and deal with natural disasters. The communities particularly those in drought and flood prone areas have generated a vast body of Indigenous Knowledge on disaster prevention and mitigation through early warning and preparedness (Roncoli et al., 2002; Anandaraja et al., 2008. The use of contemporary and indigenous climate forecasts information for farm level decision in Mozambique and Kenya is described in Lucio (1999) and Ngugi (1999) respectively.

In Zimbabwe local communities have been coping with drought by integrating contemporary and Indigenous climate forecasting (Shumba, 1999). Using IK in weather and climate prediction, local communities in different parts of Tanzania have been coping and adapting to increased climate variability normally manifested in the form of increased frequency of both droughts and floods. Prediction of impending disasters has been an integral part of their adaptation strategies. Before the establishment of conventional weather and climate forecasting, older generations especially in the rural areas in Tanzania have largely relied on Indigenous Knowledge to predict weather through observation and monitoring the behaviour of animals, birds, plants and insects (Kihupi et al., 2002; Mhita, 2006). In spite of all these benefits, IK in weather and climate prediction is under threat of disappearance due to: lack of systematic documentation of the knowledge; lack of coordinated research to investigate the accuracy and reliability of IK forecasting and finally when old people who are the main custodians of the knowledge pass away, the knowledge which has been accumulated for many years is lost. In this study, it is argued that IK can provide significant value and boosts in the improvement of forecasting accuracy and reliability if it will be systematically documented, researched and subsequently integrated in conventional forecasting system. The documentation of IK will be a good resource for the establishment of IK forecasting database in Tanzania and will be an important resource in the establishment of effective adaptation strategies to lessen the impacts of climate change. The study was therefore undertaken with two main objectives. The first objective was to identify, analyze and document local indicators used in IK forecasting over the study area. The second was to assess the perceptions of the local communities on the application and reliability of both IK and conventional forecasting in their agricultural activities in order to identify the gaps and the needs for improvement.

DESCRIPTION OF THE STUDY AREA

The study was conducted in the South-Western Highland (SWH), located between latitudes 7° and 11.5°S and longitudes 3° and 38°E (Figure 1). SWH includes Iringa, Mbeya and Rukwa regions. These regions are characterized by prolonged unimodal rainfall regime starting from November continuing to the end of April. Annual rainfall in these regions ranges from 550 mm to 3690 mm. The regions are the main producer of food crops and some cash crops such as tea. Food crops produced in these areas include maize, beans, sunflower, potatoes, finger millet, rice and assorted vegetables. Rice is mainly grown in Kyela, Usangu, Pawaga and Mbinga (along Lake Nyasa). Tea plantation in Mufindi, Njombe and Rungwe districts provide employment to majority of people in those areas and nearby regions and contribute significantly to the national income and GDP, however the tea industry and the communities in these areas are very vulnerable to climate variability and they will be even more vulnerable under the projected climate change as most models projects a reduction of rainfall in these regions and an increase in the frequency and severity of droughts and floods. Mean annual rainfall is projected to decrease by up to 6% due to the doubling of CO_2 concentration in the atmosphere (Mwandosya et al., 1998; Matari et al., 2008). The projected increase in drought frequency and severity pose a serious threat to the livelihood of people around southwestern Tanzania and to its economic development.

Methodology

Identification, analysis and documentation of the traditional indicators used for seasonal rainfall forecast in Southwestern highland were conducted, adopting similar approach to that by Kihupi et al., (2002). Kilolo and Rungwe districts from Iringa and Mbeya regions respectively were identified for data collection. The majority of the people in these two districts are mainly Hehe and Nyakyusa respectively. A total of four villages (Nguruhe and Ukumbi in Kilolo, and Kyimo and Buryaga villages in Rungwe) were sampled. The selection of village was not systematic; it was mainly based on the accessibility to the respective villages, availability of extension officers. A total of 53 respondents were randomly selected based on age factor, where all people older than 35 years were eligible to participate in the interviews. The communities that were selected in this study included pastoralists, crop producers and agro-pastoralists. Participatory Rural Appraisal (PRA) methods, key informant interviews and Focus Group Discussions (FGD) were used in data collection. Questionnaires were administered to different group of elders, where a check list that included issues on conventional climate forecasts knowledge, seasonal rainfall predictiton, knowledge on traditional indicators and past climatic events with focus on extremes guided the interviews. The collected data was analyzed and synthesized using Statistical Package for Social Science (SPSS) and Excel computer programmes. Focus group discussions were important in weighing and balancing the information collected through interviews with a view to produce generalizations that represent the traditional knowledge existing in the community. Focus group discussion of up to eight people was organized and the various techniques used within the community in weather forecasting were explored.

RESULTS AND DISCUSSION

In total, 53 respondents were interviewed in the 4

Figure 1. Location of the study area.

villages. More than 90% of the respondents were practicing farming and livestock keeping as their main source of livelihood. Climate variability and lack of farm implements were identified as the major challenges facing agricultural activities in Southwestern Tanzania. Specifically, increased frequency and severity of drought over the last few decades was identified as their biggest problem. Low availability and high price of farm implements coupled with inadequate capital to finance agricultural activities was mentioned as among the biggest challenges in their activities.

Table 1. Reliability of conventional forecasting information.

Response	Frequency	Percent
Reliable	9	17
Not reliable	9	17
Somehow	31	58
Do not know	4	8
Total	53	100

Table 2. Response on the reliability of traditional weather and climate forecasts.

Response	Frequency	Percent
Reliable	34	64
Not reliable	2	4
Somehow	14	26
Do not know	3	6
Total	53	100

Perception of the local communities on conventional climate forecast

The perception of the local communities on conventional climate forecasting was assessed. Ninety six percent (96%) of the respondents indicated that they are aware of conventional climate forecasts information issued by Tanzania Meteorological Agency (TMA), but only fifty eight percent (58%) of the respondents acknowledged using the forecasts in planning their agricultural activities. From Table 1, the response to the question on the reliability of conventional climate forecasting indicates the level of uncertainties associated with the forecasts, as only seventeen percents (17%) of the respondents indicated the forecast to be reliable, while 17% thought the forecast was not reliable while 58% of the respondents were still uncertain and thought that the forecast was just somehow reliable.

Forecast for 2009/2010 rainfall season over Southwestern Tanzania using statistical and dynamical approach

Conventional seasonal rainfall forecast normally involve the assessment of the global climate systems and its implications to the upcoming season in the targeted regions. Among the principal factors that are taken into account in the development of seasonal rainfall forecasts over East Africa are the observed and predicted Sea Surface Temperatures (SSTs) in the tropical Pacific Ocean and over the tropical Atlantic and Indian Oceans. Other potential predictors that are scrutinized include: the Outgoing Long wave Radiation (OLR), Indian Ocean Dipole (IOD) and other El-Nino-Southern Oscillation (ENSO) indices.

In the development of the forecast for the 2009/2010 rainfall season, Meteorologist and climate experts from TMA assessed the global climate systems and analyzed various ENSO indices (TMA, 2009). Apart from analyzing local and regional features, the forecast was also based on the observed and predicted sea surface temperatures over the Indian, Atlantic and Pacific Ocean. Observed anomalously warming of the sea surface temperatures (SSTs) in the central equatorial Pacific Ocean was predicted to enhance and persist up to April 2010, implying that El Nino conditions are present across the tropical Pacific and are projected to persist through April 2010. However it was noted the observed El Nino condition is not expected to be associated with very heavy rainfall like that of 1997/1998 due to lack of rainfall enhancement mechanism over the Indian Ocean as the positive IOD is not expected to develop during the season. Following these observations and analysis, areas around South Western Highland (Iringa, Mbeya and Rukwa) were therefore projected to feature normal to above normal rainfall (TMA, 2009).

Indigenous climate forecast information

The local weather and climate is assessed and predicted by locally observed variables and experiences using combinations of plant, animals, insects, and meteorological and astronomical indicators. The different weather and seasonal climate indicators used to predict rainfall over South Western Highland (SWH) are given in Table 3 - 6. Most of the respondents (94%) acknowledged the existence of traditional methods of weather and climate forecasting in their communities and 92% acknowledged using traditional weather and climate forecasts in their agricultural activities. However, as indicated in Table 2, only 64% of the respondents commented on the accuracy of IK forecasting. It has been observed that local communities in SWH rely much on forecast information from IK than from conventional method.

Table 3. Knowledge on local indicators basing on insects.

S/N	Local/Swahili name	English name	Scientific name	The sign used to relate to the rain
1	Mbalavala	Butterflies (Black bordered charaxes)	***Charaxes pollux***	Appearance of many butterflies indicate early rainfall onset and also give a prospect of a good season. Appearance of black butterflies in a particular area signal a very good rainfall season over that area.
2	Nzirafu	Ants (red)	***Treiberameisen***	Appearance of ants indicate imminent rainfall onset and signifies a prospect for good season. When flying ants are seen during rainy season this shows the sign of having more rainfall in the year.
3	Mchwa	Termite	***Ancistrotermes*** sp.	Appearance of many termites indicate near rainfall onset
4	Viwavi	Army worms	***Spodoptera exempta***	Appearance of army worms on trees during October signifies abundant rainfall in the upcoming season.
5	Vyura	Frogs	Various species	When frogs start to make a lot of noise, it indicates near rainfall onset. Also when they are noising a lot it signifies that there will be more rainfall in the coming rainy season.
6	Senene	Grass-green grasshopper	***Hesperotettix*** sp.	Occurrence of more grasshoppers in a particular year indicates less rainfall and hunger.

Table 4. Knowledge on local indicators basing on birds.

S/N	Local name	English name	Scientific name	The sign used to relate to the rain
1	Yangi yangi	(white birds)		Occurrence of Yangiyangi birds in October and November indicates imminent rainfall onset and a good rainfall season.
2	Dudumizi			Singing of the Dudumizi especially early in the morning around 5.00 A.M. in October and November is the sign of imminent rainfall onset and a good rainfall season.
3	Finyanyamba	Swallow tailed bee eater	Metro's Hirundineus	When swallow flock are seen flying all over in the atmosphere it indicates heavy rain to come at that particular time. When they appear on November it indicates imminent rainfall onset.

Indicators from plant phenology

The survey in Kilolo district of Iringa region indicated that the presence of higher than normal flowering intensity of the Mihemi (***Erythrina abyssinica***), Mikwe (***Brachystegia speciformis***) and Mpinigesi (***Prunus persca***) trees during the months of July to November are the indicative of good amount of well distributed rainfall in the upcoming season. However, a good fruits harvest from Mikusu (***Uapaca kirkiana***) trees is a signal of impending drought in the upcoming season.

In Tukuyu, Rungwe district it was found that significant flowering of Mikuyu (Ficus spp) trees is a signal of imminent rainfall onset and breeding of Mipegele (Syzygium Cordatum) trees is a signal of abundant rainfall in the upcoming season. However, the challenge here is what is considered to be a bench mark (normal). It therefore imperative that more research will be needed to quantify the norms.

Indicators from animals, birds and insects

The behaviour of animals and the appearance and movement of birds and insects are frequently used by Hehe and Nyakyusa elders to predict weather and climate in their communities. Appearance of large swarms of red ants in September to November, occurrence of large swarms of butterflies is an indicative of imminent rainfall onset and it also indicates that the

Table 5. Knowledge on local indicators based on plants.

S/N	Local name	English name	Scientific name	The sign used to relate to the rain
1	Mhemi	Kaffir boom	***Erythrina abyssinica***	Significant flowering starting from July through October Is a signal of good rains in the coming season
2	Mkwe	Bean pod tree	***Brachystegia speciformis***	Significant flowering starting from July through October is a signal of good rains in the coming season
3	Mkusu	Wild loquat	***Uapaca kirkiana***	Significant flowering and good fruits bearing is widely considered to be the good indicator of impending drought
4	Mkuyu	Fip tree	***Ficus*** spp (e.g. Ficus sycomorous)	Flowering and generation of new leaves indicates near rainfall onset.
5	Mpegele		***Syzygium Cordatum***	When it gives a lot of sap during the dry season, it indicates abundant rainfall in the coming season.

Table 6. Knowledge on local indicators based on the Moon, Sun or Wind.

S/N	Signs	Descriptions in relation to rainfall
1	North – West wind direction on November/or December	Heavy rainfall is going to fall. Also it indicates due onset of rainy season.
2	Dark moon in July accompanied by cold, ICE and snows fall	It signifies good rainy season.
3	Heart/hot in low land areas on August	It means there will be more rainfall in the coming rainy season
4	Strong wind	Strong wind during the month of July through October indicates less rainfall in the upcoming season.
5	High temperature on October and November	Signifies near rainfall onset and the prospect of a good rainfall season.
6	Change in wind direction and temperature	Signifies imminent rainfall.
7	Cold weather on July	Indicates possibility of hail stone.
8	Disposition of the new moon (slanted position)	Indicates more diseases and erratic rainfall.

upcoming rainfall season will be good. In both Kilolo and Rungwe districts the appearance of large swarms of Yangiyangi birds is an indicative of good rainfall season and imminent rainfall onset. The appearance of Pangolin (Kakakuona in Swahili) in September/October, which is a rare phenomenon, is an indicative of abundant rainfall in the upcoming season.

Indicators from air temperature and wind

In Kilolo district anomalously warming during the months of August to November is an indicator of high rainfall in the upcoming season. In both Rungwe and Kilolo, it was indicated that an occurrence of strong wind is a signal of poor rainfall season to come.

Forecast of 2009/2010 rainfall season over South-western highland using indigenous knowledge

Most of the environmental indicators that are frequently used for seasonal rainfall prediction by elders over South-western Highland are pointing towards a good 2009/2010 rainfall season. Observation by Mr. Benjamin Kongolo and Ms Teresia Kianza indicated that since July 2009

significant flowering of Mihemi (***E. abyssinica***) and Mikwe (***B. speciformis***) trees has been observed in most parts of Kilolo district which is a signal of good rains in the upcoming season. Observation by Mr. Samweli Mangulisa, Ms. Rehema Sembegalo indicated the prospect of a good 2009/2010 rainfall season due the appearance of Dark Moon in July followed by snow falling.

CONCLUSION AND RECOMMENDATION

Local indicators that are used by local communities in seasonal rainfall prediction over South Western Highland have been identified. It has been found that plants phenology are mostly used as potential predictors for seasonal rainfall prediction in both Kilolo and Rungwe districts. The appearance of Kakakuona and the behaviour of Dudumizi birds are among the best predictors used in rainfall prediction. Both Indigenous Knowledge specialists over South-Western Highland and TMA experts have predicted 2009/2010 rainfall season to feature normal to above normal rainfall (good rain). It was also noted that increased climate variability have significantly reduced the accuracy and the reliability of indigenous forecasting and it is also one of the challenge faced by TMA experts in their efforts to improve forecast accuracy and reliability, underlining the need for integrated approach in seasonal rainfall forecasting. Since IK is mainly based on relative experience and local experience, lack of benchmark makes it difficult to be harmonized and integrated into conventional forecasting system. Systematic documentation, quantification and subsequent integration of IK into conventional weather forecasting system is therefore recommended as one of the strategy that could help to improve the accuracy and reliability of seasonal forecasting information under a changing climate.

ACKNOWLEDGMENTS

This study is based on the Post-Doctoral research of the first author. The authors wish to acknowledge with thanks the financial support from the global change System for Analysis, Research and Training (START), Tanzania Meteorological Agency for providing the data and the Institute of Resource Assessment (IRA) at the University of Dar es Salaam for providing working facilities and good working environment. Special thanks are also extended to the reviewers for their constructive comments that has helped to improve the document.

REFERENCES

Anandaraja N, Rathakrishnan T, Ramasubramanian M, Saravan P, Suganthi NS (2008). Indigenous weather and forecast practices of Coimbatore district farmers of Tamil Nadu. Indigenous J. Trad. Knowl. 7: 630-633.

Gissila T, Black E, Grimes DIF, Slingo JM (2004). Seasonal forecasting of the Ethiopian summer rains. Int. J. Climatol. 24: 1345-1358.

IPCC (2007). Climate Change, The Physical Science Basis. http://www.ipcc.ch.

Johnston PA, Archer ER, Vogel CH, Bezuidenhout CN, Tennant WJ, Kuschke R (2004). Review of seasonal forecasting in South Africa: producer to end user. Clin. Res. 28: 67-82.

Kihupi NI, Kingamkono R, Rwamugira W, Kingamkono M, Mhita M, Brien KO (2002). Promotion and Integration of Indigenous Knowledge in Seasonal Climate Forecasts. Consultancy report submitted to Drought Monitoring Center (Harare, Zimbabwe). http://www.sadc.int/dmc/Research/PilotProjects/Promotion%20And%20Integration%20Of%20Indigenous%20Knowledge%20In%20Seasona.pdf.

Lucio FDF (1999). Use of contemporary and indigenous forecast information for farm level decisión making in Mozambique. Consultancy report. UNDP/UNSO p. 72.

Matari ER, Chang'a LB, Chikojo GE, Hyera T (2008). Climate Change scenario development for Second National Communication – Tanzania. TMA Res. J. 1: 40-54.

Mhita MS (2006). Training manual traditional knowledge for nature and environmental conservation, agriculture, Food security and disaster management in Tanzania. http://www.unep.org/IK/PDF/TANZANIA%20IK%20TRAINING%20MANUAL.pdf.

Ngugi RK (1999). Use of Indigenous and contemporary knowledge on climate and drought forecasting information in Mwinyi district, Kenya. Consultancy report. UNDP/UNSO p. 28.

Nyenzi BS (1999). Mechanisms of East African rainfall variability: PhD Thesis.– The Florida state University, College of Arts and Science p. 184.

Ogallo LB (1989). The spatial and temporal patterns of the East African seasonal rainfall derived from principal component analysis. Int. J. Climatol. 9: 145-167.

Roncoli C, Ingram K, Kirshen P (2002). Reading the Rains: Local Knowledge and rainfall forecasting in Burkina Faso. Soc. Nat. Resour. 15: 409-427.

Shumba O (1999). Coping with drought: Status of integrating contemporary and Indigenous climate/drought forecasting in communal areas of Zimbabwe. Consultancy report. UNDP/UNSO p. 72.

TMA PRESS RELEASE (2009). Tanzania seasonal rainfall outlook for September – December 2009. Tanzania Meteorological Agency. http://www.meteo.go.tz/wfo/seasonal.php.

Zorita E, Tilya FF (2002). Rainfall variability in northern Tanzania in the march-may season (long rains) and its links to large scale climate forcing. Clin. Res. 20: 31-40.