INNSPUB

International Journal of Agronomy and Agricultural Research (IJAAR)
ISSN: 2223-7054 (Print) 2225-3610 (Online)
http://www.innspub.net
Vol. 3, No. 5, p. 1-9, 2013

RESEARCH PAPER

OPEN ACCESS

Comparative performance of scientific and indigenous knowledge on seasonal climate forecasts: A case study of Lupane, semi- arid Zimbabwe

Ignatius Chagonda[1*], Adelaide Munodawafa[1], Francis T. Mugabe[2], Veronica Makuvaro[1], Philip Masere[1] , Cyril T. F. Murewi[3]

[1]*Faculty of Natural Resources Management and Agriculture, Midlands State University, Bag 9055, Gweru, Zimbabwe*

[2]*Directorate of Research and Resource Mobilisation, Chinhoyi University of Technology, Private Bag 7724, Chinhoyi, Zimbabwe*

[3]*Faculty of science and Technology, Midlands State University, Bag 9055, Gweru, Zimbabwe*

Article published on May 17, 2013

Key words: Indigenous knowledge forecast, scientific forecast, seasonal climate forecast, season quality, smallholder farmers.

Abstract

Seasonal climate forecasting (SCF) is weather prediction over a period ranging from 3-6 months period. Forecasting can be done using scientific forecasts (SF) or indigenous knowledge forecasts (IKF) systems. Forecast results can be very fruitful to smallholder farmers in semi-arid areas where rainfall is highly variable. Effective use of SCF has faced challenges including: rainfall variability, access to forecast information, interpretation of forecast results and generation gap. There is limited research on comparative performance of the two forecasts. The research seeks to evaluate comparative performance of the two forecasting methods in predicting outcome of the following rainfall season. The study was carried out in Daluka and Menyezwa wards of Lupane district, south-western Zimbabwe, which receives annual average rainfall of 450-650 mm. Focus group discussions and personal interviews were used in 2008/09 and 2009/10 seasons to capture farmers' experiences and knowledge on SCFs and their application. The predicted outcome of the IKF and SF were compared with actual rainfall recorded from the predicted period. Results indicated high dependence on the use of the IKFs by Lupane farmers in predicting the outcome of the following season's rainfall. Both the IKF and SF predicted inadequate rainfall in the two consecutive seasons and the results concurred with recorded rainfall in Daluka ward in the two seasons and in Menyezwa ward in 2009/10 season only. Results demonstrate that in the absence of SF, farmers may use IKFs. It is imperative that the two forecasts complement each other to increase farmer adaptation to climate variability.

* **Corresponding Author:** Ignatius Chagonda ✉ chagondai@msu.ac.zw, ichagonda@yahoo.com

Introduction

Weather forecasts are issued to save lives, to save property and crops and to tell us what to expect in our atmospheric environment in a particular area during a stated time period (Buckle, 1996; Donald, 2000). Seasonal forecasters use observations from the ground and space along with formulas and rules based on experience of what has happened in the past and then make their forecast. Achieving the goals of SCF is through correct forecast which increases food security while poor forecast causes more harm and reduce adaptation chances (Hansen, 2005).

The two main sources of forecasts are indigenous and scientific knowledge forecasts. The IKF system on one hand, are a body of knowledge or bodies of knowledge of the indigenous people of a particular geographical area that they have survived on for a long time and has been passed on from previous generations and adapted to the local area (Mapara, 2009; Mahoo and Mpeta, 2010). Much of it is embodied in the art, history and culture of the people concerned (Neela, 2003). One of the reasons that IKF plays a big role in local communities is that it is used as a basis for decision pertaining to food security, education, natural resources management and seasonal forecast prediction among others (Gorjestani, 2000; UNEP, 2007).

While many local communities have for years relied on indigenous forecasting methods for planning agricultural activities, there has been an increasing use of modern seasonal climate forecasts (scientific forecast) in many parts of Africa over time (O'Brien and Vogel, 2003; Patt, *et al.,* 2007; Roncoli, *et al.*, 2009). A scientific forecast is a long term climate prediction based mainly on sea surface temperature (SST) anomalies (International Research Institute (IRI) 2008). It is a product of pre-season forums that bring together everyone in the world involved in seasonal forecast development relevant to, for instance, Southern African Development Community (SADC), to develop best forecast for the region through a consensus. Local National Meteorological Services, for example the Department of Meteorological Services of Zimbabwean (DMSZ) then downscale the regional product to country-specific forecasts. These probabilistic products have been used by many farmers for crop management decision making (Ziervogel 2003; Patt and Gwata 2003).

Although the IKF and SF are widely used in agricultural decision making, farmers often face challenges in their use. For instance, very little IKs are documented, neither are they communicated freely from one user to another, they are not validated thus difficult to implement them at a broader scale (Mahoo and Mpeta, 2010; Chagonda, *et al.*, 2010). Generation gap also impedes effective use of both SF and IKF in that young people are not familiar with; neither can they interpret their local IKs well. Similarly, their elders cannot interpret the probabilistic nature of the SF due to low literacy rate.

On a similar note, SFs' probabilistic nature, the coarseness of their coverage (Mahoo and Mpeta, 2010) and prediction of seasonal rainfall amount only but not distribution, makes comprehension and hence application by end users, a challenge. This may be worse off if the forecast becomes politicized and is released upon being edited by politicians first who may fear that, users may respond negatively to the outcome of the forecast if prediction reveals a drought year, by lowering the area under staple crop. Furthermore, the broader prediction nature of SF contradicts the IKF system in that the latter's prediction strength is at local level and this has a strong implication on precision and hence adoption by local people. The challenges to use of the two forecasts have a strong bearing on their application in farming decision making by farmers in semi-arid areas.

Despite these challenges, there is a lot of potential in the use of both forecasting methods by farmers in rain-fed areas. There is however limited research information on the comparative performance of SF and IKF in predicting seasonal rainfall. The objective of the study was therefore to evaluate the consistency of SF and IKF in predicting outcome of the coming rainfall season using the actual seasonal rainfall measured in the predicted season.

Materials and methods

Site characteristics

The study was carried out in Lupane district, which is located in the south western part of Zimbabwe. Lupane center is situated in Matabeleland North province which is 170 km from Bulawayo along Bulawayo, Victoria Falls road. The study sites, Menyezwa and Daluka wards (Fig.1), are elevated at an altitude of about 1080m above sea level. The district lies in Natural Region (NR) IV of Zimbabwe and receives an average annual rainfall of less than 500 mm which is erratic and crop failure due to drought is common (Vincent and Thomas 1962). The NRs are a classification of the agricultural potential of the country, from NR I, which represents the highest altitude and wettest area receiving more than 1000 mm of rainfall per year, to NR V that receives the lowest rainfall amounting to less than 450 mm per year and is dry. Average temperatures for the sites are 24°C. The dominant soils that are found in the district are the Kalahari sands which comprise deep, unconsolidated and well drained tertiary sands of Aeolian origin which are highly infertile (Nyamapfene 1991).

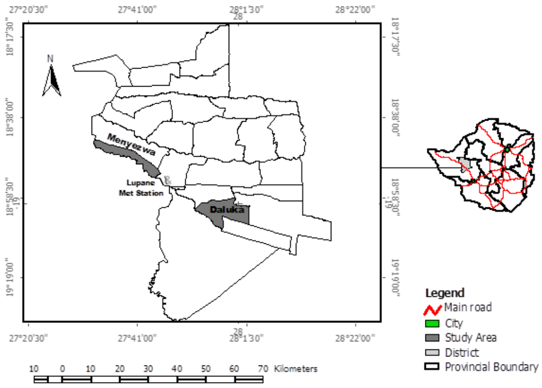

Fig. 1. Map showing Daluka and Menyezwa wards of Lupane district.

The majority of people residing in these areas are Ndebele speaking people who have stayed in the area for a long period of time and are well versed to their tradition which they cherish greatly. They are small-holder farmers whose livelihoods depend heavily on rain-fed agriculture based on production a variety of crops ranging from maize, sorghum, cowpeas, groundnuts, melons, pumpkins, peal and finger millets. These farmers also domesticate cattle, donkeys, goats as well as various types of domestic fowl.

Research procedure

Two wards (Daluka and Menyezwa) were selected in Lupane district for the study. Lupane district was chosen on the basis that it is one of the areas in NR IV of Zimbabwe, which is semi-arid, has very variable rainfall patterns and is one of the vulnerable communities to effects of climate variability and change. These communities' poor resource base makes adaptation a major challenge for them. Choice of the wards was based on the fact that they were more than 50 km apart and it was assumed that that would have a bearing on the amount of rainfall that was going to be received as well as higher chances of having different IK indicators. From these wards, three villages were chosen using systematic random sampling technique so that a wider scope of different IK indicators as well as farmers' experiences on their IKs could be captured. From Daluka ward, Daluka, Strip road and Mafinyela villages were chosen while from Menyezwa ward, Menyezwa, Masenyani and Banda villages were chosen making a total of six villages. Five farmers were chosen at random from each village, factoring in gender and different age groups, hence a total of 30 farmers participated in the study in the 2008/09 and 2009/10 seasons.

Seasonal climate forecast development and farmer engagement in the forecasts

Farmer engagement was through use of Focus Group Discussions (FGDs), where farmers were grouped by gender, age and according to villages or wards they came from. This was done to capture broader responses of IKF indicators that different groups use to forecast the outcome of the seasonal rainfall. Personal interviews were also held to get wider and more specific experiences from elderly farmers selected at random from the different villages, where their long experience of knowledge and experience with IKF and climate change was solicited. Farmers who were involved in the interviews were the same as those who participated in the FGDs.

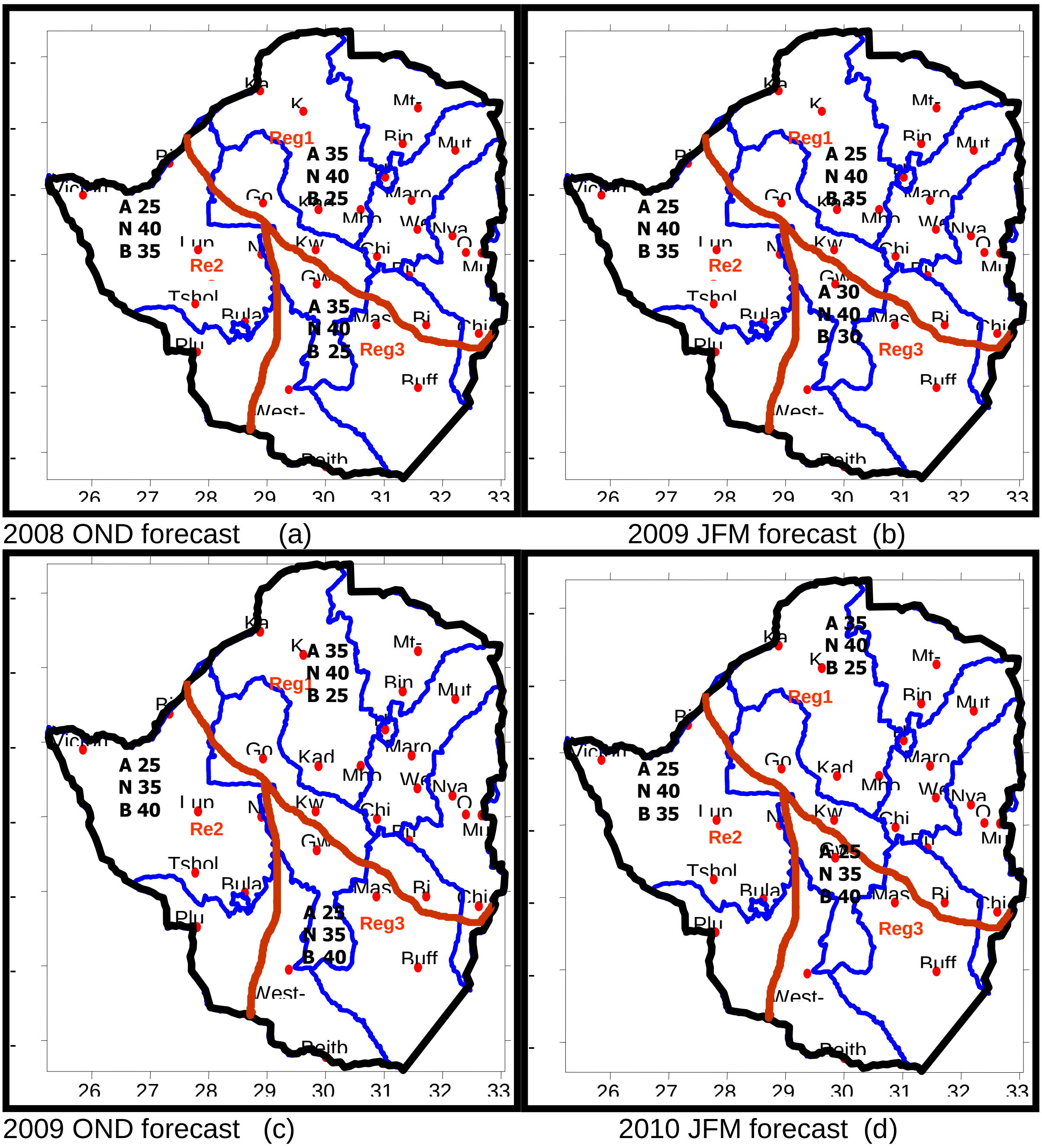

Fig. 2. Seasonal climate forecast from the Department of Meteorological Services of Zimbabwe for both halves of the 2008/09 and 2009/10 season.

Participants included farmers from the two study areas, Agricultural Research and Extension (AREX) staff, Department of Meteorological Services of Zimbabwe staff and researchers from the Midlands State University, who together explained fully interpretation and use of SF to farmers. Farmers were the first to indicate what their local indicators predicted about the outcome of the coming season. The local Meteorological staff followed with their scientific forecast prediction. At least three farmers in each village were given a rain gauge and a diary to record daily rainfall whose seasonal total was used as the bases for comparing the outcome of the IK and scientific forecasts at the end of the season.

Results

Indigenous knowledge forecasting

Farmers from the two wards of Lupane concurred on what their IK indicators show, indicating their experiences with a variety of plants and animal species as well as natural indicators of good and bad season (Table 1) that they use to predict outcome of the rainfall season. Farmers predicted that the 2008/9 and 2009/10 seasons would both receive low rainfall. This was evidenced by low fruiting pattern that was characteristic of local indigenous fruit tree species (*Rhus lancea* and *Lennae descolor*). One elderly farmer from Daluka ward highlighted that trees like *Rhus Lancea* can have a lot of fruits at the beginning of the season and people might mistake it for a good season yet the tree may go on to shed off the fruits. This then indicate that the season could have an abrupt end, thus a poor harvest for farmers even if rainfall could be sufficient and this could be due to mid season droughts.

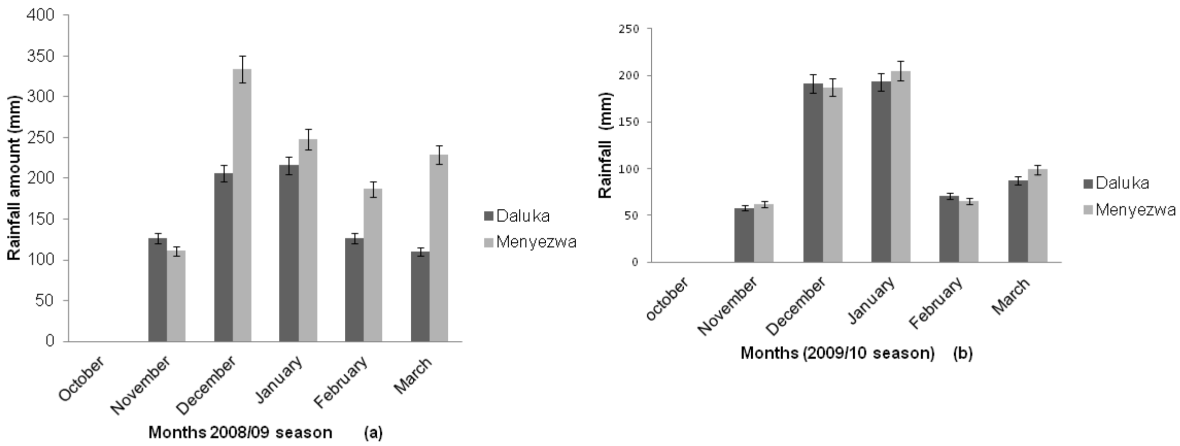

Fig. 3. Observed rainfall amount (mm) for Daluka and Menyezwa wards of Lupane district in the 2008/9 (a) and 2009/10 (b) seasons.

Farmers also highlighted evidence of a dry season ahead in form of the direction of butterflies movements and colour changes of tiny tree dwelling frogs. Furthermore, there was a consensus that there was no haziness in the sky, extended cold spells and dominant north easterly winds all having a strong inclination towards a poor season (Table 1). Rainfall distribution was said to be very unpredictable as it was common that farmers from adjacent villages could have significantly different harvests in the same season.

Scientific forecasting

The scientific forecast predicted that both the first (October, November and December 2008) and the second half (January, February and March 2009) of the season would receive normal to below normal rainfall (Fig 2a and b) with similar chances (40 %) for both halves, of normal rainfall and 35 % chances of below normal rainfall. The prediction also shows low chances (25 %) of an above normal rainfall for the same season. This prediction was applicable to both wards as they fall in the same meteorological region 2 (Fig. 2). In the 2009/10 season, the scientific forecast predicted that, the first half of the season would have below normal to normal rainfall for both wards with highest chances (40 %) of below normal rainfall, 35 % chances of normal rainfall and again low chances (25 %) of an above normal rainfall (Fig. 2c). The second half was predicted to have 40 % chances of normal rainfall, 35 % chances of below normal rainfall and again very limited (25 %) chances of above normal rainfall (Fig 2d). Generally the prediction pointed towards a low rainfall season for the successive seasons.

Recorded rainfall

The total amount of rainfall that was recorded at Daluka and Menyezwa wards for the 2008/09 farming season was 485 mm and 1105 mm respectively, (Fig 3a). On a monthly time scale, more rainfall was received in Menyezwa than Daluka except for November. In the first half of the season, Menyezwa and Daluka wards received 445 mm and 178 mm and in the second half, 560mm and 314 mm of rainfall respectively. December and January were the wettest months in both wards, while there was no rainfall event in October for both sites. All the five months, except November, received significantly ($p< 0.05$) higher rainfall amount in Menyezwa than Daluka (Fig 3a) thus Menyezwa ward received significantly higher total seasonal rainfall than Daluka ward.

Table. 1. Indicators used by Lupane farmers to forecast outcome of the coming season.

Good season	*Bad / drought year season*
• *Rhus lancea* and *Lannea discolor* trees produce lots of fruits • *Azanza garckeana* do not fruit well • Heat waves experienced characterized by a lot of noise from cicadas • Early haziness soon after winter • Prevalence of whirl-winds after winter • Tiny tree dwelling frogs turning brownish • Rain birds making a lot of noise • Butterflies seen hovering in the air from north to south starting in October	• *Rhus lancea* trees produce few fruits • *Lennae descolor* produce fruits but aborts them before the rains. • Extended winter cold spell period stretching to spring (August to September) • North easterly winds dominant • Tiny white frogs appear in trees • Lots of thunderstorm without rains • Early rains starting from early October

In the 2009/10 season, a total of 600 mm of rainfall was recorded in Daluka ward while Menyezwa recorded slightly higher (618 mm) of rainfall (Fig 3b). There was no rainfall event in October for both sites while the wettest months for the season were December and January where Menyezwa recorded 187 mm and 205 mm whilst Daluka recorded 191 mm and 193 mm respectively (Fig 3b). The first and second half of the season saw Daluka ward receiving 249 and 351 mm while Menyezwa received 249 and 369 mm of rainfall respectively. On a monthly basis, Menyezwa recorded more rainfall in November, February and March. Total seasonal rainfall for the sites was not significantly ($P<0.05$) different from each other (Fig 3).

Discussion

Farmers in Lupane indicated a variety of flora, fauna as well as natural indicators that predicted low rainfall in the two consecutive seasons. Tree species that farmers highlighted for example *Rhus Lancea (isigangatsha) and Lannea discolor,* bear edible fruits that can be prepared into various dishes, thus alleviating hunger for the farmers during the dry season. The elderly farmer's sentiments on the interpretation of *Lannea discolor* bearing lots of fruits and later dropping them, explains the essence of involving and tap finer details from elderly people who have lived in these areas for long periods of time and have vast experience in the use of their IKs in rainfall forecasting. Use of fruiting pattern of certain tree species by farmers to predict seasonal rainfall outcome, concurred with findings in Burkina Faso, by Roncoli (2001). Edible fruits are also a common feature in rural communities at specific times of the year such that communities have taken them as part of their livelihoods. Natural indicators use by the farmers in form of wind movements, thunderstorms and animal species to show dryness or wetness of the season, were also reported by Mutambanengwe, *et al.*, (2008) and Ajibade and Shokimi., 2003 in southern and eastern Africa and in Nigeria respectively.

Historical records (1950-2005) from the Met department shows that normal rainfall range for the study sites for OND was 208-258 mm and for JFM was 333-358 mm. Daluka ward received rainfall that fell in the below normal category in both halves of the 2008/9 season. Rainfall received in Menyezwa in the 2008/9 season when compared with historical records, was well above normal in both halves of the season and this contradicted with both the IKFs and SF prediction of a low rainfall and a normal to below normal rainfall prediction respectively. Results from Menyezwa created a major challenge for farmers in the area in believing in scientific forecasts as well as their own IKF methods. It is likely that the deviation of the observed and predicted rainfall could be on one hand due to the fact that the scientific forecasters failed to dawn scaled to capture variation over a small area due to its coarseness as was also observed by Mahoo and Mpeta (2010). Alternatively, the IK indicators could have been wrongly interpreted by Menyezwa farmers who had very few elderly people to interpret IKFs better (Chagonda *et al.*, 2010).

In the 2009/10 season, measured rainfall was in the same range with historical data in the first and second half of the season in Daluka. A similar agreement was also observes in the first half of the season and slightly above normal rainfall in the second half of the season in Menyezwa. Farmers' IKFs had strong inclination towards low rainfall in the 2008/09 and 2009/10 seasons and this was consistent with measured rainfall in Daluka in the 2008/09 season. Both the scientific and the IKF were, however in agreement with measured rainfall in Daluka for the two years of study as well as in Menyezwa in 2009/10 season given that the IKF gives a once off forecast which is qualitative in that it does not quantify the amount of rainfall predicted. Although the 2009/10 season had predictions of below normal rainfall in the first half, both sites received normal rainfall. The scientific prediction for the second half of the 2009/10 season was however in agreement with the measured rainfall. The scientific forecast gives a very wide range of rainfall prediction that does not define the exact amount, for example below normal to normal or normal to below normal can end up in either a normal season of below normal season. The consistency between IKF and SF in the two years of study for both wards is in agreement with results found in Tanzania, Mahoo and Mpeta (2010), where the seasonal forecast results from IKF were similar with those from scientific forecast. Daluka farmers were impressed by their ability to translate their IKF to match with scientific forecast and this lured a lot of non participating neighboring farmers to be engaged in the project.

Conclusion and recommendations

The IKF and SF predicted low rainfall for the 2008/09 and 2009/10 seasons and this was consistent with measured rainfall in the two consecutive seasons in Daluka ward and 2009/10 season only in Menyezwa ward. Results from this study demonstrate that, in the absence of the scientific forecast, farmers may use IKFs as they have proved to be consistent with SF in the two years. Alternatively the two forecasts may complement each other through their integration in seasonal climate forecasting thereby imbedding adaptation strategies in communities' existing knowledge of climate variability and indigenous prediction systems which is being recommended by Huq and Reid (2007). The non-existent measurement of rainfall by farmers does not warrant nullification of their IKF as the result does highlight the need to cross-check (with measured data) farmer derived information as a forward step in validating their IKs. There is need however to consider more years in such studies as two seasons may not be enough to ascertain consistency of the two forecasting methods in predicting the coming season's rainfall.

Acknowledgement
This publication is an output from a project funded by CCAA/IDRC and DFiD (Grant number 104144). The views expressed are not necessarily those of CCAA/IDRC/DFiD. The authors would particularly like to thank staff from the Met and AGRITEX departments as well as the communities who participated in the research for their participation and assistance.

References

Ajibade LT, Shokemi. 2003**.** Indigenous approaches to weather forecasting in Asia L.G.A. Kwara State, Nigeria Indilinga. African journal of indigenous knowledge systems **2**, 37-44.

Buckle C. 1996**.** Weather and Climate in Africa, Addison Wesley Longman Limited, Essex, England.

Chagonda I, Churi J, Dieye A, Houenou B, Hounkponou S, Kisiangani E, Kituyi E, Lukorito C, Macharia A, Mahoo H, Majule A, Mapfumo P, Mtambangwe F, Mugabe FT, Ogallo L, Ouma G. Wanda G. 2010. Integrating meteorological and indigenous knowledge-based seasonal climate forecast for the agricultural sector: Lessons from participatory action research in sub-Saharan Africa. CCAA learning paper. Ziervogel G, Opera A. ed.

Donald CA. 2000**.** Meteorology today, an introduction to weather, climate and the environment, 6th Edition.

Gorjestani N. 2000. Indigenous knowledge for development, opportunities and challenges. *Paper presented at the UNCTAF conference on traditional knowledge,* Geneva

Hansen JW. 2005. Integrating seasonal climate prediction and agricultural models for insights into agricultural practice. Philosophical transactions of the royal society. *Biological sciences:* Royal society publishing **360** (1463), 2037-2047.

Huq S, Reid H. 2007. Community-based adaptation An IIED Briefing: A vital approach to the threats climate change poses to the poor, IIED Briefing, London:

International Research Institute for climate prediction (IRI). 2008. http://iri.Columbia.edu/climate/forecast/tutorial/2/index.htm accessed 5/01 /12.

Mahoo H, Mpeta E. 2010. Combining indigenous and scientific weather forecast knowledge in climate risk management in semi-arid areas of Tanzania. *Paper presented at the workshop on "achieving benefits of enhanced service delivery by national meteorological services in eastern and southern Africa"* Dar es Salaam.

Mapara J. 2009. Indigenous Knowledge Systems in Zimbabwe: Juxtaposing Postcolonial theory, *Journal of Pan African studies* **3**, (1).

Mugabe FT, Mubaya CP, Nanja D, Gondwe P, Munodawafa A, Mutsvangwa E, Chagonda I, Masere P, Dimes J, Murewi C. 2010. Use of indigenous knowledge systems and scientific methods for climate forecasting in southern Zambia and north west Zimbabwe, *Zimbabwe Journal of Technical Sciences* **1**,(1).

Mutambanengwe F, Giller K, Mapfumo P, Chokowo R, Maria R, Adjei-Nsiah S, Baijuka F, Mvula A. 2008. *Farmer's perceptions lead to experimentation and learning*. http://www.agriculturesnetwork.org/magazines/global/dealing-with-climate

Neela M. 2003. Participatory rural appraisal. Methodology and application, Ashock, Kumour Mittal. Concepts Publishing Company New Delhi 110059 India.

Nyamapfene K. 1991. Soils of Zimbabwe. Nehanda publishers.

O'Brien K, Vogel C. 2003. A future for forecasts. In: O'Brien K. Vogel C. ed. Copying with climate variability: the use of seasonal climate forecasts in Southern Africa. Ashgate Press. Aldershot, 197-211.

Patt AG, Ogallo L, Hellmuthm M. 2007. Learning from 10 years of climate outlook forums in Africa. *Science* **318**, 49-50.

Roncoli C, Jost C, Kirshen P, Sanon M, Ingram KT, Woodin M, Some L, Quattara F, Sanfo BJ, Sia C, Yaka P, Hoogenboo G. 2009. From accessing to assessing forecast: an end to end study of participatory climate forecast dissemination in Burkina Faso (West Africa) *climate change*, **92**, 433-460.

Roncoli C, Ingram K, Kirshen P. 2001. The cost and risks of copying with drought: livelihood impacts and farmer' responses in Burkina Faso. *Climate Res* **19**, 119-132.

UNEP (United Nations Environment Programme). 2007. Nature Conservation and Natural Disaster Management: The role of Indigenous Knowledge in Kenya.

Vincent V, Thomas RG. 1962. An agro-ecological Survey of Southern Rhodesia Part 1: Agro-ecological Survey: Government Printers. Salisbury, 1-217.

Ziervogel G, Calder R. 2003. Climate variability and rural livelihoods: assessing the impact of seasonal climate forecasts in Lesotho. Area **35**, 403-417.