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Towards a Framework for the Integration of Traditional Ecological Knowledge and Meteorological Science in Seasonal Climate Forecasting: The Case of Smallholder Farmers in Zimbabwe

Thulani Dube[1*], Philani Moyo[2], Sibonokuhle Ndlovu[3] and Keith Phiri[4]

[1,3,4]Department of Development Studies, Faculty of Humanities and Social Sciences, Lupane State University, P.O Box AC255, Ascot, Bulawayo, Zimbabwe
[*]Telephone: +2639883098-9, [*]E-mail: thutsdube@gmail.com
[1,2]Department of Sociology and Anthropology, Faculty of Social Sciences and Humanities, University of Fort Hare, 50 Church Street, East London, South Africa

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ABSTRACT Global evidence shows that seasonal climate forecasting can be a useful strategy in adapting to the effects of climate change on agricultural production. Meteorological science based seasonal climate forecasting has been broadly promoted as an important adaptation tool in this regard. However, calls are now mounting for the integration of meteorological based forecasting knowledge with traditional ecological knowledge based systems of seasonal forecasting to minimize system deficiencies in forecasting. Using a mixed methods approach, the study investigates the interface between the two knowledge systems and what integrating them would entail in practice in Matobo District, Zimbabwe. The paper finds that farmers are already utilizing both types of knowledge albeit in an uncoordinated fashion. Those farmers that integrate the two knowledge systems tended to make more definitive farming decisions concerning seasonal climate patterns. The paper recommends a more systematic parallel integration system that recognizes the importance of both knowledge systems.

INTRODUCTION

Evidence of the negative impact of climate change on smallholder farmers' livelihoods in developing countries is mounting (Comoe and Siegrist 2015; Moyo and Dube 2014; Mubaya et al. 2012; Shackelton and Shackelton 2011; IPCC 2007). Pricope et al. (2013) argue that yields from Africa's rainfed agriculture could decrease by as much as fifty percent in the next 30-35 years as a result of the effects of climate change. However, research from Zimbabwe, Kenya, Burkina Faso and India amongst other countries shows that seasonal climate forecasting can be a useful tool in adapting to the effects of climate change in agricultural production (Hansen et al. 2011; Shankar et al. 2011; Roncoli et al. 2002 and Ribsey 1999). Improved scientific climate forecasting methods have made it possible to present farming communities and relevant stakeholders with seasonal forecasts three to six months before the cropping seasons (Blench 1999). These forecasts enable farmers to make adaptation decisions in agricultural production. It has been established that farmers who receive quality seasonal forecasting information are able to make decisions that lessen agricultural risks emanating from climate change and variability (Unganai 2013; Philips et al. 2002). However, in spite of the evident benefits of seasonal climate forecasting, literature shows that there are several shortcomings of the meteorological seasonal forecasts, which are predominantly used and supported (Ribsey et al. 1999; Hansen 2002). Calls have therefore been increasing for the integration of meteorological forecasting methods with indigenous knowledge based forecasting methods with a view to improve the effectiveness of forecasting systems (Green and Raygorodetsky 2010; Berkes 2009; IPCC 2007 and Eakin 1999).

Ziervogel and Opere (2006) point out that there are two main types of seasonal climate forecasts, namely, meteorological climate forecasts and traditional ecological knowledge based climate forecasts. Meteorological forecasting refers to climate forecasting normally provided by national meteorological departments such as the Zimbabwe Meteorological Services Department in the case of Zimbabwe. This type of forecasting is derived by collecting and analyzing instrumental data on parameters such as sea surface temperatures, wind direction and speed, temperature, humidity and atmospheric pressure patterns. Traditional ecological knowledge (more broadly known as indigenous knowledge systems) is defined as,

...A cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment. Traditional ecological knowledge is an attribute of societies with historical continuity in resource use practice (Berkes 2000: 1252).

Various indicators are used in traditional ecological knowledge to forecast seasonal climate. Some of these indicators include fauna, flora, astrological constellations and the general local physical environment (Speranza et al. 2010: 303). For example, the color of the sky, wind direction, changes in the distribution of animals and plants, flowering patterns of plants, behavior of ants and insects have been found to give insight into impending weather patterns amongst local communities (Lebel 2013).

The two seasonal climate forecasting mechanisms cited above have proven themselves to have both individual strengths and weaknesses. These strengths and weaknesses have led to calls for the integration of the two systems to create a solid system of seasonal climate forecasting to improve climate change adaptation efforts amongst smallholder farmers (Alexander et al. 2011; Berkes and Berkes 2009; Ziervogel and Opere 2006). In spite of several calls for the integration of these two systems of seasonal climate forecasting, little headway has been made because several challenges abound. This paper attempts to address this quest for integration by addressing the following research questions:

(1) What opportunities and challenges exist in the integration of indigenous knowledge systems based climate forecasting and meteorological climate forecasting systems?
(2) What model of integration can be suitable for maximizing the benefits from both systems?

The main objective of the paper was to investigate current seasonal climate forecasting information usage amongst smallholder farmers in Matobo District and to recommend possible pathways for the integration of traditional ecological knowledge and Western scientific knowledge.

Practical Challenges in Integrating the Two Systems of Knowledge

One fundamental challenge in the integration process of the two knowledge types is that they emerge from what is considered to be two incompatible knowledge generation traditions. Meteorological forecasts are considered to be scientific work while indigenous knowledge has variously been labeled with terms other than science. The differences in the two types of knowledge are evident in Alexander et al.'s (2011: 477) definitions.

Science - (is) here defined as a set of statistically analyzed data or instrumental records - rests on precise definitions of independent and dependent variables that can be empirically measured and that demonstrate acceptable levels of reliability and validity.

Traditional Ecological Knowledge (TEK) is a subset of indigenous knowledge that can be understood as 'a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of leaving beings (including humans) with one another and with their environment.' (Alexander et al. 2011: 477)

It is evident from the definitions above that the main difference between Western science and traditional knowledge is that traditional knowledge is thought to be non-methodological, described with such terms as 'lay' and 'tacit' while Western science on the other hand is understood to be largely distinguished by its application of formal methods. Methodological differences are also reinforced by Roncoli et al. (2002: 410), who define science as '…knowledge generated by expects using recognized and rigorous approaches to observation and experimentation.' Although Roncoli and her colleagues do not attempt to compare indigenous knowledge systems and Western-based meteorological knowledge systems, it is clear that rigor and measurement are seen as the defining characteristics of the latter type of knowledge. Lusendo et al. (2003: 1483-4) point out that 'although traditional climate forecasting methods may be poorly understood, they may nonetheless be based on intrinsically scientific foundations that account for moderate observed forecast skill.' These differences between the two knowledge systems, whether real or perceived have contributed to the challenges faced in terms of integrating the two forecasting systems.

It is however important to note that part of what is called indigenous knowledge systems permeates into the spiritual realm, which makes it difficult to measure and authenticate as knowledge. For example, in a study conducted in Southern Uganda, Orlove et al. (2010: 265) note that some communities make use of signs such as dreams. The authentication of such knowledge creates problems in verification and acceptability. Roncoli et al. (2002) argue for a separation between two types of knowledge as discussed here between what they call shared forecasting knowledge and selective forecasting knowledge. Shared forecasting knowledge relates to all climate forecasting knowledge that all interested community members of a particular locality can learn by observation to forecast seasonal climate. Such observations may include but are not limited to wind direction and strength, flora and fauna, insect, birds and animal behavior. This may be called the science of indigenous knowledge as it follows simple but established observation methods that lead to identifiable results. 'In the shared domain of environmental knowledge, farmer forecasts resemble scientific methods in their reliance on the systematic observation of natural phenomena' (Roncoli et al. 2002: 422). Selective forecasting knowledge on the other hand is largely spiritual knowledge. This kind of knowledge is possessed by 'spiritualists, who have inherited powers or acquired skills by virtue of initiation or election by the spirits…' (Roncoli et al. 2002: 413). For example, it is argued by the same authors that farmers' interpretation of wind direction resemble conventional science in that they also acknowledge the influence of oceans on rainfall patterns. Spiritualists are believed to receive messages through dreams and visitations by deities. This knowledge held is only available to the select that have spiritual access.

RESEARCH METHODOLOGY

Study Site

Zimbabwe has five recognized agro-ecological regions, namely, regions one, two, three, four and five. Region one is the most productive and prime agricultural region in Zimbabwe with the highest rainfall. The regions become progressively poorer and drier in precipitation as you move towards region five. The larger part of Matobo district lies in region five, which is the driest of the five ecological regions. The district suffers frequent droughts with an average annual precipitation of 350mm in the decade ending in 2010 (Zimbabwe Meteorological Services Department Data, unpublished statistics). According to the results of Zimbabwe's 2012 census, Matobo district is the second largest district in Matabeleland south province with a population of 93,991. The district has a total of 25 (twenty-five) wards composed of over 21,000 households (Zimstats 2012).

Data Collection Methods

The study utilized a mixed methods approach comprising three data collection methods namely a survey, key informant in-depth interviews and focus group discussions. The survey questionnaire was administered to a total of four hundred smallholder farming households chosen using a multistage cluster sampling technique. The questionnaire gathered data on household characteristics and choices for sources of information on seasonal climate forecasting. Key informants in-depth interviews gathered information from stakeholder government departments' officials including AGRITEX (Agriculture and Extension Services Department), Zimbabwe Meteorological Services Department and the Department of Climate Change Management. Indepth interviews sought information on how these government departments interacted with smallholder farmers in generating and disseminating seasonal climate forecasts. A total of four focus group discussions were held across Matobo District. One focus group discussion was held in each of the four wards that were randomly selected in the district namely, Sontala, Tokwe, Mantakeni and St. Anna. The focus group discussions sought to understand farmers' current practices in using meteorological and indigenous knowledge systems based seasonal climate forecasts.

FINDINGS

Meteorological Forecasts in Matopo District: Not Fit for Purpose?

In Zimbabwe, seasonal climate forecasts are produced and disseminated by the Zimbabwe

Meteorological Services Department through the Agro-meteorology sub-department in the form of probabilistic forecasts in three terciles-above normal rainfall, normal rainfall, and below normal rainfall. For example, the overall forecast for Zimbabwe in October to December 2013 was above normal thirty-five percent, normal forty percent, and below normal twenty-five percent (Zimbabwe Meteorological Services Department website 2014). A similar forecast was repeated for Zimbabwe in 2014. The technical nature of this information has proven to be a challenge for both farmers and AGRITEX officials who are the disseminators. This difficulty in understanding the information often meant that forecasts were often deterministically interpreted leading to a distrust of the outcomes of the forecasts where the target was missed. The problem was aggravated by the fact that most AGRITEX officers were not expressly trained in understanding climate change and the seasonal climate forecasts.

While the Meteorological Services Department gives seasonal climate forecasting information in probabilistic terms, evidence from focus group discussions showed that AGRITEX officers often further refined the forecast information into deterministic form, telling farmers that there would be adequate or inadequate rain. The terciles with the highest probability percentage were normally taken as the de facto forecast for the season. While farmers often took this forecast, the danger was that it was not as deterministic as stated. Deterministic forecasts stand a high risk of giving an erroneous forecast, which could discredit the scientific process of deriving seasonal climate forecasts. This would undermine farmers' trust in the forecasting process.

The study found out that smallholder farmers in Matobo district were conscious of the importance of knowing about climate change trends, especially seasonal climate forecasts. However, the means of accessing information were a challenge. Table 1 shows the dominant means of accessing meteorological climate change information. It will be observed from the table that the majority of farmers (186) who receive climate change information receive it from the radio. The majority of farmers (192 respondents) do not have access to a formal climate change source on a regular basis. Fifteen households (15) received it from television. This may be attributed to the fact that television sets are more expensive and difficult to acquire. Newspaper availability was also limited because of its price. Most newspapers cost about USD 1. This was a high amount for such poor rural communities. The Internet was only used by college level graduates in the survey.

Table 1: Climate change information sources used by farmers in Matobo District

Climate change information sources used by farmers	*Count of responses (n=400)*
Television	15
Newspaper	5
Internet	2
Radio	186
No source of information	192

Source: Survey data

Forty four percent (44 percent) of the respondents did not make any efforts to seek seasonal climate forecasts in preparation for forthcoming seasons. Respondents who did not seek such information mostly attributed their lack of interest to the fact that forecast information was either unreliable or that the weather was beyond the control of science and therefore God was ultimately the final authority. Other reasons given included the fact that there were no sources of information even if the respondents would have wanted to seek information. It is evident that the low levels of climate information seeking behavior were related to the difficulties communities encounter in accessing information. One focus group participant at St Anna village noted that:

We are not able to find information on whether in any season there will be good rains that can allow us to plant well. Most of us just know that the rains have fallen, and tomorrow we will plant. We do not get to search if say I plant today may be there will be no rains again in the near future. Those that know these things must make an effort to give us information on what the weather will be and what we must do. Even if things do not turn out as said but it might be close (Focus group discussion participant 4, St Anna).

Other reasons advanced by farmers for not seeking climate change information prior to farming seasons is that farmers felt that they did not know where to seek for the information and therefore they never took the effort to even search for the information.

What happens is that we do not have knowledge about rainfall patterns in forthcoming seasons. We do not have anyone to tell us about that. There is no one who works closely with us to let us know about those things. When it rains we just get into our fields and start planting, if we win we win, if we lose we lose. AGRITEX officials teach us about farming only, they do not teach us about climate change (St Anna Focus Group Discussion, Participant 6).

It may thus be noted that some farmers were not seeking seasonal climate forecast information because they did not know whom to approach for the information. There is need to alert farmers about the availability of seasonal climate forecasting information and the centers where this information can be availed. The study also established that current climate change information flow was largely restricted to community members who owned radios. Community members with radios were most likely to hear about climate change and seasonal weather forecasting. Those community members who had no radios relied on secondhand information from those who had the gadgets. This meant that community members who had radios stood a better opportunity to maximize on climate change adaptation and have improved yields as compared to members without access to radio. The ability to possess a radio was seen as a distinguishing factor between those that have and those that do not have access to climate change information. Financial affluence was thus closely related with possessing a level of climate change knowledge.

The above point is affirmed by survey data (see Table 2). This data shows that households at the lower end of the income bracket (USD 0-49 and USD 50-99) tended to be the ones with people with the least knowledge about climate change. The higher the income bracket the more knowledgeable about climate change the respondents were. For example, in the category of households earning USD 200 to USD 299 per month, ninety-two percent of the respondents reported that they had heard about climate change. If the two top ends of income bracket households earning above USD 200 per month are combined, there is a total of 33 households. Of these 33 households, 25 (76 %) reported that they had heard about climate change while 8 (24 %) said they had never heard about climate change. On the other end of the scale, the lowest income bracket of USD 0-49 had 157 respondents. Of these respondents, 97 (62%) had never heard about climate change while 60 (38%) mentioned that they had heard about it. The pattern of association between income levels and knowledge levels about climate change is thus clear.

Lack of climate change meteorological information may thus be attributed to the inability to purchase gadgets and items that transmit such information in the form of radios and television sets. Reliance on television and radio for climate change information dissemination has the risk of expanding the gap between the rich and the poor in rural areas. Those with television sets and radios are more privileged in terms of access to information through the radio, thus enabling them to make agricultural management decisions that help them produce more yield than the poorer households.

The use of climate change information for adaptation decision-making was dependent on the perceived level of credibility and trustworthiness of the information. In cases where indigenous knowledge systems and meteorological

Table 2: Household average monthly income and knowledge of climate change (n=400)

	Average monthly household income						
	$0-49 per month	*$50-99 per month*	*$100-199 per month*	*$200-299 per month*	*$300+ per month*	*Unknown*	*Total*
Yes (I have heard about climate change)	60 38.2%	65 64.4%	20 46.5%	13 92.9%	12 63.2%	20 30.3%	190 47.5%
No (I have never heard about climate change)	97 61.8%	36 35.6%	23 53.5%	1 7.1%	7 36.8%	46 69.7%	210 52.5%
Total	157 100.0%	101 100.0%	43 100.0%	14 100.0%	19 100.0%	66 100.0%	400 100.0%

Source: Survey data

knowledge projections were in harmony, farmers found it easy to base their decisions on such forecasts. However, where there was a divergence, farmers preferred indigenous knowledge systems. Meteorological climate forecasts were criticized for lack of precision with regards to geographical location of climatic events. Respondents pointed out that forecasts were too broad and in many instances not location specific. As one respondent noted:

Sometimes they say that a lot of rain is going to fall say in Matabeleland South. But sometimes this refers to Kezi or White Water. The rest of the region might not have the rains. So, it is difficult to trust the forecast strongly. You just hope that it will be so but you cannot be certain. (Tohwe focus group discussion, Participant 3)

This weakness of meteorological climate forecasting is evident also on the SARCOF (Southern Africa Regional Climate Outlook Forum) forecasts that were published with the following disclaimer:

This outlook is relevant only to seasonal (overlapping three monthly) time scales and relatively large areas and may not fully account for all factors that influence regional and national climate variability, such as local and month-to-month variations (intra-seasonal) (SARCOF, August 2014).

Empirical evidence shows that the majority of smallholder farmers in Matobo district use indigenous climate knowledge for coping and adaptation purposes. This is in contrast with the widely held view that meteorological seasonal climate forecasts are the main source of information for farmers with regards to climate change adaptation (see Hansen 2002; Jagtap 2002; Philips et al. 2002). Table 3 shows the responses from the survey concerning which type of knowledge farmers primarily use for seasonal climate forecasting.

Table 3 shows that fifty-two percent of the respondents use indigenous knowledge systems exclusively. Another twenty-six percent use a combination of both indigenous knowledge systems and meteorological knowledge systems. This brings the tally of people who use indigenous knowledge systems to seventy-eight percent. This points to the fact that indigenous knowledge systems for seasonal climate forecasting play a major role in agricultural decision-making for climate change adaptation in Matobo district. A mere twelve percent of the respondents said that they exclusively used meteorological seasonal climate forecasting for decision-making. The remaining eleven percent reported that they did not seek seasonal climate forecasts before the start of the rainy season. These statistics call into question the celebration of meteorological climate forecasting as the magic bullet in climate change adaptation. There is thus a need to rethink seasonal climate forecasting information methodologies to streamline and promote indigenous knowledge systems in line with what farmers are actually using.

Table 3: Knowledge systems primarily used in seasonal climate forecasting by smallholder farmers in Matobo

Knowledge systems primarily used in seasonal climate forecasting by smallholder farmers in Matobo District (n=400)	
Meteorological systems based forecasting	12%
Indigenous knowledge systems based forecasting	52%
A combination of both meteorology and indigenous knowledge (equally)	26%
Not Applicable (The respondent did not seek seasonal forecasts in their farming)	10%

Source: Survey data

There are several reasons why farmers prefer to use indigenous knowledge systems. According to information gathered from focus group discussions, one of the reasons was that meteorological climate information is not easily accessible for those without radios. However, traditional ecological knowledge was available to all who were willing to learn and apply it as it was based on the immediate local environment. For example, one indigenous knowledge systems specialist pointed out that,

The point is that those of us without radio and television have to trust in the old way of doing things. Currently the people who hear about seasonal forecast are those with radios. So if you do not have a radio, we use the old ways of forecasting and it works. Some people with radios also use this method (Indigenous knowledge systems specialist interview 5).

Another reason cited for the use of indigenous knowledge systems ahead of meteorological climate information was that people trusted indigenous knowledge systems from their working experience in predicting seasonal climate over many decades. Lastly, but not least respondents in focus group discussions felt that seasonal climate forecasting through IKS was more readily available in their environment. They did not need to spend money to access it.

DISCUSSION

Towards a Framework for the Integration of Meteorological Forecasts and Indigenous Knowledge Forecasts

The foregoing findings indicate that indigenous knowledge systems were an important part of Matobo farmers' repertoire of tools in making farming decisions. The majority of people in Matobo thus have a high regard for indigenous knowledge systems. The people who regarded them as not important were either well-to-do people or Christians. These two groups of people looked down on indigenous knowledge systems for two reasons. The well-to-do people had alternative climate change information sources like radio and television, and therefore hardly bothered to understand this kind of knowledge. Christians rejected this knowledge on a religious basis. They argued that some of the knowledge was linked to traditional religion, which was incompatible with their faith. These findings are different from those made by Orlove et al. (2010:258) in Uganda who found out that in Uganda farmers generally felt that '*...there was no incompatibility between knowing God and a reliance on indigenous knowledge… Rather, they (farmers) explained that God created an orderly world with regular patterns and signs for humans to observe'*. This observation shows that the acceptance of the integration of indigenous knowledge systems and Western science in seasonal climate forecasting may be partly driven by local cultural attitudes. Religious beliefs play a crucial role in this regard.

It is important to note from the findings in this study, the idea of integrating indigenous knowledge systems and meteorological systems for seasonal climate forecasting is not something new. Local community members in Matobo have already been practicing this. As discussed above, twenty-six percent of the farmers interviewed used a combination of indigenous knowledge systems and meteorological knowledge in seasonal climate prediction. This was also confirmed by AGRITEX officials who indicated that communities were aware of the parallel existence of the two knowledge systems, which they systematically evaluated and made sense of in their decision-making for climate change adaptation. As one AGRITEX official noted,

When the knowledge gets to the farmers it starts to be integrated, knowledge from meteorological services department and knowledge from the farmers, which we call indigenous knowledge systems. Farmers have particular indicators to predict the season (Interview: AGRITEX Provincial Agronomist).

An organic integration of the two knowledge systems was therefore an ongoing phenomenon in Matobo District. This integration of indigenous knowledge systems with conventional meteorological methods serves several important purposes. The fact that several farmers are already using an integrated approach shows that it is beneficial. The use of both methods would immensely increase the scope of information available because the two types of knowledge have different strengths and weaknesses. The range of information available could thus be immensely improved by the integration of these two knowledge systems. Studies by Orlove et al. (2010) and Ziervogel and Opere (2010) show that in many African communities indigenous knowledge systems are used together with scientific knowledge to varying extents.

Since there is limited coverage of instrumental information from the meteorological services department in Matobo, indigenous knowledge systems are therefore important as a climate change knowledge system. Contrary to the view by Alexander et al. (2011: 447) that '…indigenous knowledge can provide complementary information that has particular value in determining patterns of climate change for regions in which there are limited instrumental records', this paper finds that the holders of this knowledge refuse to subordinate it to instrumental knowledge as they see it as their primary and trusted knowledge system. Therefore while seeking to establish some kind of collaboration between meteorological (Western based) science and indigenous knowledge systems, the suggestion that indigenous knowledge systems should complement or become an appendage of Western science should be questioned because there is already overwhelming evidence that in Matobo district (and perhaps elsewhere) that indigenous knowledge systems are the main source of seasonal climate forecasting. There is also evidence that this information system has served its purpose to the satisfaction of the users. Indigenous knowledge systems in Matobo are the bedrock knowledge system for making adaptation decisions at a local household level. Indigenous knowledge systems (IKS) are used as the framework of knowledge meaning that other sources of knowledge are understood and interpreted in the context of what the IKS knowledge frame points to.

This paper thus proposes a framework for the integration of the two knowledge systems. The proposed integration of the two knowledge systems should be along the lines of what Berkes (2009) calls the coproduction of knowledge where both conventional science and indigenous knowledge systems practitioners develop working partnerships and mutual respect. Knowledge coproduction brings together different types of knowledge in order to strengthen resilience against climate change. This coproduction of knowledge should not be seen as something entirely new that researchers formulate from some kind of super wisdom. The general frame of procedure should be initially extracted from what communities are doing and, then perfected.

A key issue to consider in the integration of indigenous knowledge systems and instrumental meteorological knowledge is the fact that indigenous knowledge is highly localized. It was noted in Matobo district that particular tree species are only dominant in certain places. Therefore, knowing indicators in one region does not make one a universal specialist. This is a strength and weakness of IKS based seasonal forecasting. It is a strength because it addresses climate issues relevantly at the local level. It is a weakness because this entails a massive amount of work if the integration is attempted at a national scale. Therefore, this suggests that integration of these knowledge systems should take place at the minutest spatial level possible (perhaps at village or ward levels).

The last but perhaps most crucial challenge in the integration of the two knowledge systems is epistemological (Table 4). This pertains to what it means to know and what knowledge is acceptable as admissible. The two types of knowledge have significant differences. Meteorological knowledge is gathered through standardized measurements while indigenous knowledge often utilizes a fuzzy logic approach. A sustainable, conflict free and non-aggressive integration process should therefore pursue a mutually parallel structure. This would allow for a workable coexistence, which requires the humble recognition of the key strengths of each knowledge system. In other words, this paper

Table 4: The parallel integration of indigenous knowledge systems and meteorological knowledge systems in seasonal climate forecasting

Generation of indigenous knowledge forecasts		*Generation of meteorological forecasts*
1. Knowledge of local ecology	Epistemological division between meteorology based forecasting and indigenous knowledge systems based forecasting	1. Data gathering on sea surface temperatures
2. Observation and learning of local indicators		2. Meeting of SARCOF experts and generation of SADC forecasts
3. Fuzzy logic generation from indicators		3. Zimbabwe Meteorological Services Department downscales forecast SADC to Zimbabwe
4. Forecast generation from composite indicators		4. Meteorological Services Department transfers information to AGRITEX
5. Community-based verification process of forecasts through farmer peer confirmations		5. AGRITEX transfers information to farmers
6. Decision generation by farmers	a. AGRITEX meetings with farmers to facilitate analysis and comparison of both forecasts and decision options. b. Synthesised final decisions reached and taken by individual farmers	6. Decision generation by farmers

Source: Authors

argues for a parallel integration of the two types of knowledge. This concept would entail a working together of the two knowledge systems without one threatening or imposing on the other. Each knowledge type would contribute vital knowledge and skills.

In view of the fact that the two knowledge systems are based on largely different epistemological traditions, it is necessary and perhaps even beneficial to allow the two systems to develop separately. The schema below shows a scenario where each knowledge system develops and functions in its established way. The schema below graphically reproduces these processes and proposes a point of convergence for integration.

Once each knowledge system has produced its forecast, it is recommended that a government agency of some kind (likely headed by AGRITEX) convenes local workshops in wards or villages to discuss both meteorological forecasts and IKS forecasts. As this and other studies (see Philips et al. 2002) have shown, the two systems more often than not converge in their forecasts. This paper calls this model a parallel integration. The two systems produce their forecasts separately (parallel) but they are integrated and synthesized at results level. This helps to overcome the seemingly insurmountable epistemological and other challenges. A synthesized analysis will provide more solid grounds for decision-making for adaptation by smallholder farmers.

CONCLUSION

This study found out that smallholder farmers in Matobo District in Zimbabwe employ a multifaceted system of seasonal climate forecasting drawing from both traditional ecological knowledge and meteorological knowledge systems. The study notes that farmers who had access to both knowledge systems expressed a greater confidence level in decision-making related to precipitation patterns. Farmers were of the opinion that where both systems forecasted similar results, there was greater certainty that the season would turn out as forecasted. However, where there was conflict in forecasts farmers invariably trusted their interpretation of traditional ecological knowledge. Although traditional ecological knowledge and meteorological forecasts emerge from different epistemological backgrounds, the study finds that smallholder farmers in many instances already integrate the two systems in decision-making at a household level.

RECOMMENDATIONS

In view of the finding that the larger proportion of smallholder farmers utilize indigenous knowledge systems in seasonal climate forecasting, this paper recommends that more efforts should be directed towards ensuring a greater integration of this knowledge system into mainstream seasonal climate forecasting. This study has shown that farmers have greater confidence in indigenous knowledge systems for seasonal climate forecasting than in meteorological knowledge. An integration of the two knowledge systems would result in a hybrid forecasting system that would promote better agricultural yields for smallholder farmers. The paper thus recommends a coordinated integrated system preferably led by a central government agency such as the Agricultural Extension Services Department.

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