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Indigenous knowledge systems, seasonal 'quality' and climate change adaptation in Zimbabwe

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ABSTRACT: Farmers use a variety of local indicators for weather forecasting and climate prediction, in order to adapt to climate variability and change. Integrating indigenous knowledge systems (IKS) with the efforts of climate scientists can contribute to effective on-farm adaptation initiatives. The objective of this research was to identify IKS used by Zimbabwean farmers to predict seasonal weather patterns, and their adaptation strategies in response to these predictions. The information was collected using focus group discussions, household surveys, and ethnographic interviews. Most farmers (72.2%) indicated that low rainfall is the major limitation to agricultural production. Without access to reliable local scientific weather forecasts, the farmers use tree phenology, animal behaviour and atmospheric circulation as sources of local knowledge to predict the onset and 'quality' of the season. These forecasts are then used for designing crop choices, planting dates and agronomic practices. Our results show that the use of IKS in local farming communities is an effective way of building coping and adaptation strategies. The results also revealed that indigenous knowledge is being eroded and is becoming less accurate in seasonal weather prediction. Therefore, future studies on IKS could explore the use of multiple methods that combine indigenous knowledge and scientific weather data in order to obtain more complete and accurate information for the prediction of local area seasonal characteristics.

KEY WORDS: Indigenous knowledge · Smallholder farmers · Weather forecasting · Food security · Agronomy

1. INTRODUCTION

The Intergovernmental Panel on Climate Change (IPCC) (2007) emphasized that many developing countries, especially in Africa, will be increasingly exposed to climate change impacts in the future. This is as a consequence of the widespread low adaptive capacity, low resilience and susceptibility to climate and environmental shocks in these countries. By 2050, average temperatures in southern Africa are projected to be 2–4°C higher and rainfall 10–20% less than the 1961–1990 baselines (Unganai 1996, Nyong et al. 2007, Lobell et al. 2008). Sub-Saharan Africa is already being severely and disproportionately affected by climate change and is vulnerable to future variability, and yet has the least capacity to respond (Boko et al. 2007). This is because of the large number of communal and smallholder subsistence populations living in rural areas. Indeed, the low resources and poor technology that prevail in the rural populations result in limited options for adapting to climate change (Mendelsohn et al. 2000, Nyantakyi-Frimpong 2013). Development of adaptation strategies thus has great potential for reversing the adverse impacts on agricultural productivity and hence food security.

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In southern Africa, agriculture is a complex and challenging operation due to a number of factors, among them low-fertility soils, changing social and political situations, unfavourable economic environments and a variable climate (Osbahr & Allan 2003). Research has shown that efforts by farmers to address these challenges and use of indigenous knowledge systems (IKS) are key components in this context (Gukurume 2014, Kolawole et al. 2014, Roudier et al. 2014, Saitabau 2014, Mapfumo et al. 2015). One of the key characteristics of IKS includes the use of various forms of traditional indicators to predict weather and climate and also to respond to climate risk factors (Kalanda-Joshua et al. 2011).

Indigenous knowledge or local knowledge is generally defined as the understanding of the local environment by local communities, and the practices, techniques and technologies they use to cope and adapt to climate change and variability (Ajibade 2003). Most climatic models lack localised climate data and scenarios. Climate scientists can benefit from local observations of weather (Kirkland 2012). Understanding the basis of indigenous peoples' coping and adaptation strategies is critical if climate change research and development efforts aimed at these communities are to be successful. Consideration of local IKS will enhance decision-making at local levels as well as influence policy processes and policy choices at the national level (Adger et al. 2007). Indigenous people have ways of predicting weather within a season and from season to season. These predictions help them to decide what and when to plant for a particular season as well as when to perform certain operations within a season.

Scientific knowledge has, over the past decades, increasingly taken priority over local knowledge and practices in the research and development of agricultural systems (Walker et al. 1999). Early warning systems for disasters and climate-related shocks were traditionally channelled through religious and cultural methods such as oral literature, poems and songs, which unfortunately lost recognition and utilization in the context of climate change adaptation in the same period. However, in recent years, particularly in the past decade, there is an emerging and dominant view that places emphasis on local knowledge as a key component of an agricultural system and the view that scientific knowledge must enhance local knowledge, rather than displace it (Walker et al. 1999, Osbahr & Allan 2003, Kalanda-Joshua et al. 2011, Maconachie 2012, Jain 2014). Despite this shift towards recognition of IKS in climate change adaptation in agriculture systems, there is evidence that increased rainfall variability and temperatures have reduced smallholder farmers' confidence in indigenous knowledge, and hence have reduced the adaptive capacity and increased the vulnerability of these farmers to climate change (Kalanda-Joshua et al. 2011). In addition, skewed use of scientific knowledge and weather and climate predictions has proven to be a major constraint for farm-level decision making, as they do not incorporate IKS, which farmers already live with. In the same context, farmers are more willing to use seasonal climate forecasts when these forecasts are presented with and compared to the local indigenous climate forecasts (Patt & Gwata 2002, Gana 2003).

Forecasting seasonal characteristics ('quality') is complex and imperfect. The majority of communal farmers cannot access scientific weather information. Where the weather information has been accessed, it is at a scale that is not usable by the local indigenous peoples. Weather information is given for a whole province, but the distribution and amount of rainfall vary at a much smaller scale. However, indigenous peoples in these communities have historically been able to adjust cropping and livestock systems with little or no access to scientific information of weather forecasting, and thus they continue to rely on IKS for whether prediction and forecasting. This indigenous knowledge is based on long-term observations and experiments (Kirkland 2012). Practitioners of indigenous knowledge draw deductive inferences from phenomena which are deliberately and systematically verified in relation to experience (Scott 2011).

The objective of this study was to explore the use of IKS by communal farmers to predict seasonal characteristics and subsequent adaptation in the face of climate variability and change.

2. MATERIALS AND METHODS

2.1. Study site

The study was carried out in the Chiredzi District in Masvingo Province, Zimbabwe (18° 55′ S, 29° 49′ E; Fig. 1). The district falls within the semi-arid areas, lying entirely within Agro-Ecological Region 5 of Zimbabwe where frequent food shortages occur due to uncertainty of rainfall (Vincent & Thomas 1960). Rainfall in this region is often erratic, with widespread drought in most years. The mean annual rainfall ranges from 300 mm in the southern parts of the district to 400 mm in the northeastern parts. The annual mean, maximum and minimum temperatures in

Fig. 1. Location of the study sites in the Chiredzi District of Zimbabwe

the district are 24.8°C, 27.4°C (November) and 22.3°C (July), respectively (Vincent & Thomas 1960).

2.2. Data collection

Farming households were sampled to collect both primary and secondary data. Data were collected using a structured questionnaire, focus group discussions, key informant interviews and literature surveys. Sampling of the study area was achieved through the help of government agricultural extension (AGRITEX) officials in the area who assisted in the identification of wards in which to carry out the study (i.e. smallholder communal farming wards). A ward, in this case, consisted of an average of 15 villages of about 40 households each. Four wards, 2 on either side of the Runde River, were chosen for this study. Farmer lists were produced for each village by the respective AGRITEX officers for each ward. Five villages were then randomly chosen from each ward so as to have a sample representing the whole ward. Within the randomly selected villages, 5 farmers were also randomly selected using the farmer lists in each village to give 25 respondents per ward. The respondents identified for this study were all dry land smallholder farmers. A total of 100 respondents were included in the study.

Key informant interviews were conducted with key district personnel as well as village heads and elderly farmers (i.e. older than 65 years of age) — the elderly are assumed to have institutional memory and are de facto custodians of indigenous local knowledge. Quantitative data collected were analysed using the Statistical Package for Social Sciences (SPSS).

3. RESULTS

3.1. Socioeconomic characteristics of the respondents

The mean age of the respondents was 49 yr. These were people who were born and grew up in the Chiredzi District. About 67 % of the respondents had some level of formal education (Table 1).

Almost a third (28.9 %) of the households had no other sources of income outside of the subsistence agricultural activities. Less than 10 % of the household received more than US $350 mo^{-1} (the poverty datum line at the time of the study) from sources outside the farm (Fig. 2). Most households depended on farming activities with no access to credit facilities (73.2 %).

3.2. Repondents' observations of climate change and variability

The results show that 86.6 % of the respondents were of the opinion that there have been some changes in the climate over the last 20 yr (Fig. 3). The

Table 1. Levels of formal education of survey respondents

Level	% of respondents
No formal education	33.0
Primary	38.1
Secondary	26.8
Tertiary	2.1
Total	100.0

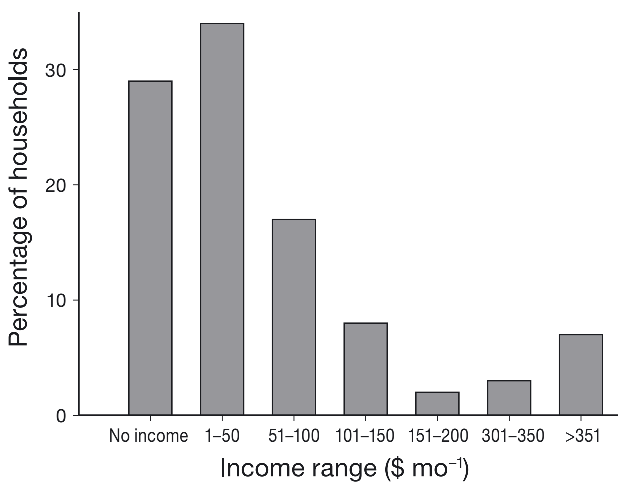

Fig. 2. Level of income (in US $) from sources other than household agricultural activities among survey respondents from the Chiredzi District of Zimbabwe

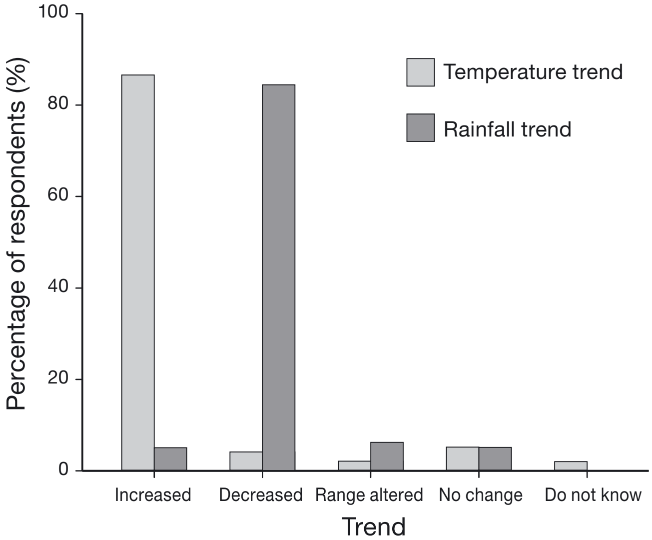

Fig. 3. Perceived temperature and rainfall trends in the last 20 yr in the Chiredzi District of Zimbabwe

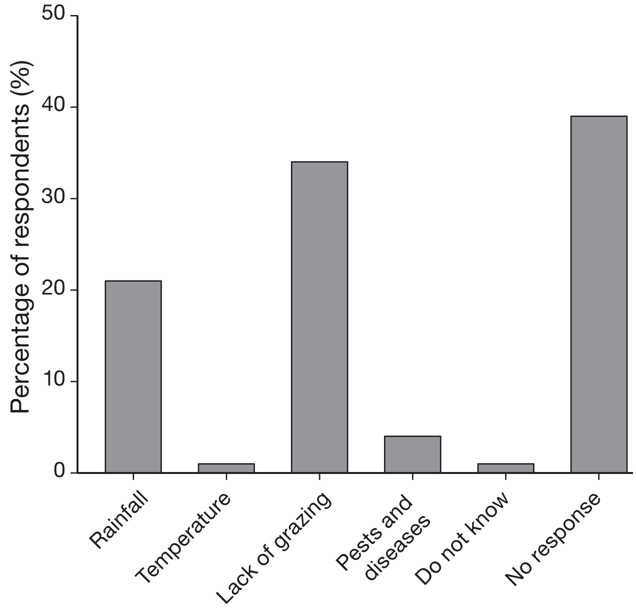

Fig. 4. Factors challenging cattle production according to survey respondents in the Chiredzi District of Zimbabwe

majority of the farmers indicated that there has been an increase in temperature over the last 20 yr (Fig. 3), and focus group discussions all concurred that it has become hotter in Chiredzi during that time period. Respondents also indicated that the amount of rainfall has decreased over the past 20 yr (Fig. 3). Although the farmers were aware of the meteorological weather forecasts, they have not linked them to climate change and variability.

3.3. Limitations to agricultural production

Farming in the Chiredzi District is mostly rainfed. Only 3.1 % of the households indicated that they had access to some form of irrigation, mainly for market gardening during the dry season. The farmers are mainly subsistence farmers who use animal-drawn (71.1 %) and handheld implements (25.8 %). Farmers perceive low rainfall as the greatest challenge to agricultural production over the past 10 yr. The majority (75.3 %) cited low rainfall as a challenge to their farming, followed by lack of inputs (13.5 %). A lesser number (3.4 %) cited high temperature as limiting agricultural production. Probed as to the main challenge to maize cropping, almost all respondents (92.8 %) highlighted low rainfall. The rest were not aware of the reasons for crop failure. More than 50 % of the farmers indicated that a lack of grazing and low rainfall affect livestock production (Fig. 4).

A summary analysis indicates that the primary limiting factors to smallholder agricultural production are low rainfall and lack of inputs (88.8 %), while a small percentage of the respondents also cited high temperature (3.4 %) and lack of draught power (7.9 %) as limiting factors (Table 2). These results show that the indigenous farmers in Chiredzi understand that there is variability and change in climate. Cropping and adaptation decisions tend to be based on certain indicators that they have used over the years.

3.4. Prediction of seasonal characteristics based on indigenous knowledge

While seasonal forecasts are important, farmers require short-term local area forecasts to make cropping decisions. Farmers indicated that they needed to be able to know when the season would start to enable them to prepare for planting. They also require information on when rainfall will occur in their local area. Our survey showed that indigenous knowledge was used both for long- and short-term rainfall predictions. These indigenous knowledge

Table 2. Factors limiting agricultural production according to survey respondents

	% of respondents
Low rainfall	75.3
High temperature	3.4
Lack of draught power	7.9
Lack of money to buy inputs	13.5

indicators can be classified into tree phenology, animal behaviour and atmospheric observations. The long-term predictors are used in conjunction with short-term, within-season predictors.

Environmental indicators that famers use to predict the coming rainy season are available for observation at different times of the year. Observations which farmers rely on most are fruit production of certain trees and the behaviour of birds and insects throughout the year. They also observe the intensity and direction of winds. Table 3 shows indicators that are used by indigenous farmers to predict the 'quality' of the coming season.

The communal indigenous farmers assert that they are able to predict when the rains are about to start. Table 3 shows 2 such indicators used by farmers, and Table 3 describes predictors used to forecast the rains within a short period of time.

3.5. Coping and adaptation to climate change using IKS

Farming is the primary occupation for all of the sampled households, although some combine a small level of non-farming activities. The high degree of dependence on farming activities will require major adaptations in the farming sector, as this sector is directly affected by climate change. Based partly on their perceptions and local indigenous knowledge of climate variability, the farmers have adopted different strategies to cope with the consequences of climate change and to manage future climate variability.

Farmers indicated that they will employ different strategies at the crop, field, farm and community level to adapt their cropping to climate variability and change. Table 4 summarizes these adaptations at different levels in the Chiredzi District.

4. DISCUSSION

We noted that indigenous knowledge was restricted to serve of elderly respondents and village heads. Younger people and women were hesitant to provide their indigenous knowledge, which may mean that indigenous knowledge is not widely shared in these communities. This result concurs with the studies of Easton & Roland (2000) and Ramphele (2004), who found that women are often sidelined in IKS in com-

Table 3. Indigenous knowledge system indicators for seasonal and season 'quality' prediction

Name	Characteristics
Indicators for whole season quality (rainy or drought)	
Colophospermum mopane (mopani) sprouting	Level of sprouting and colour of leaves during spring months; initial heavy flowering indicates good rains; subsequent heavy flowering indicates poor rains
Sclerocarya birrea (mupfura) fruiting	Heavy fruiting indicates imminent drought in the coming rainy season
Chochomela birds	When these birds appear in summer, it is a sign of a good rainy season
Kwarakwara birds	When these birds appear in summer, it is a sign of a good rainy season
Madzetse (big frogs)	If these are heard in dry streams in summer, they signify a good rainy season
Ciconia ciconia (stork)	Appearance of these birds indicate a good rainy season
Time of winds	If at the end of October there is too much wind, it indicates a poor rainy season to come
Moon	Dense halo around the moon at night indicates a good rainy season, and that it may rain in few days
Grasshoppers	Abundances and hatching of grasshoppers in mid-season indicates a good rainy season
Indicators of the start of the rainy season (short-term rainfall prediction)	
Lone baboon	If a lone baboon crosses the area in early summer, it indicates onset of rains
Millipedes	Big millipedes producing sounds in the soil indicate onset of rains
Indicators of very short predictions (within season)	
Cuckoo bird (kohwera bird)	Whenever this bird produces its crying sound, rains will fall within 2 days
Bucorvus leadbeateri (Southern ground-hornbill) - Dendera bird	When this bird is heard, it rains the following day
White frog	This small frog stays on trees. If it croaks in summer, rains will fall within a day
Wind direction	Winds that come from the southeastern indicate that it will rain that week
Cloud types	Dark clouds preceding strong winds means rainfall in a few hours

munities. Most elders and village heads acknowledge traditional knowledge as an important source of weather pattern information for the area. From focus groups, it was evident that indigenous knowledge is traditional knowledge passed from generation to generation. In general, elderly respondents were happy to explain the weather indicators.

When asked whether a change in climate has occurred in their lifetime, most farmers interviewed responded that climate variability has increased. In their view, it rains less than before, rains begin late or end prematurely, and dry spells are more frequent. These perceptions of farmers show a high level of understanding of climate change occurrence, although a small proportion of respondents failed to show such understanding. This small proportion should be considered positively as a target for the extension system, to be provided with information on climate-change-related issues (Leautier 2004). Perceived changes in temperature have a significant influence on the choice of climate change coping and adaptation strategies (Mbilinyi et al. 2005, Nkomwa et al. 2014). Perceived changes in average temperatures could explain the cultivation of more crop varieties, use of short-growing crop varieties and use of soil and water conservation measures (Table 4). This is supported by Eriksen (2005) and Yesuf et al. (2008), who concluded that adoption of cropping adaptation strategies is largely influenced by current perception and levels of climatic variables.

Farmers indicated that the rainfall season now starts late, but some years it could be different. This concurs well with scientific climate studies which indicate that rainfall may become more erratic, and shifts in seasons would also result from climate change (Lobell et al. 2011, Mavhura et al. 2013). This would make planning for cropping and other agricultural activities difficult for local farmers.

Temperature increases and declines in rainfall will increase environmental stresses (Robinson & Herbert 2001), and will necessitate continuous coping and adaptation (Mavhura et al. 2013); the magnitude of these effects on the local communities will be influenced by their level of vulnerability to climate change (UNDP 2010, Hiwasaki et al. 2014). Despite increased climate variability, people living in marginal areas have historically managed their farming and resources effectively. They have observed the changing tree phenology and animal behaviours over the years. As a result, they hold knowledge of how wildlife and plants behave and reproduce as an indicator of certain weather patterns (Pilgrim et al. 2008).

Table 4. Coping and adaptation strategies used by farmers, synthesized from focus group discussions

Scale	Timing		
	Before the season	During the season	After the season
Crop	Variety selection for stress tolerance	Replanting with early maturing varieties	
Field	Staggered planting dates	Changing crops when replanting	Grazing of failed field for animal maintenance
	Low-density planting	Increasing plant density when replanting	
	Intercropping		
	Soil and water management strategies		
	Delayed fertilizer use	Split application of topdressing fertilizer	Spreading of anthill soil to fields
Farm	Diversified cropping	Shifting crops between land types	
	Plot fragmentation		
Community level	Social networks	Matching weeding labour inputs to expectations of the season	Asset sales for cereal purchases
	Off-farm employment networks		Food transfers
	Increase livestock assets		Migration employment
	Assess cereal stocks		

Increased climate variability, however, has weakened the farmers' confidence in local forecasts of rainfall patterns based on tree phenology and animal behaviour. Some elders recalled times, in the past, when they were able to predict the onset of the rains accurately. Now, they are open to alternative sources of rainfall information. They do not resist the use of scientific information or regard it as threatening to local IKS. This is because local IKS is robust and dynamic (Roncoli et al. 2002, Davis 2005). Farmers pragmatically mix indigenous knowledge with extension advice and meteorological forecasts. Even in using their indigenous knowledge, farmers often combine a variety of environmental and spiritual traditions. The farmers' observations are related to movements of weather systems that influence the rainfall pattern over the area. In South Africa, for instance, farmers' perceptions were that IKS were usually right, but not always (Ziervogel 2001). Generating useful forecasts therefore calls for a deep understanding of both the needs of specific user groups — particularly those engaged in agriculture — and the benefits and challenges forecasts may present to these users (Ziervogel 2001, Zurayk et al. 2001). Farmers concurred that, just as meteorological weather forecasts are too generalised and unreliable, their indigenous knowledge has also become less reliable because of climate change.

Local communities have developed coping mechanisms and adaptation strategies which include a mix of crops, selection of more drought-tolerant crop varieties and sites, staggering planting of crops and adjusting land and crop management to suit the prevailing conditions. This has also been reported in other studies (Yesuf et al. 2008, Mavhura et al. 2013, Hiwasaki et al. 2014). These strategies are selected partly based on consideration of IKS predictions. More than 90% of the 100 rural households sampled reported having faced severe food shortages, especially during the months of November to January. Local people in the Chiredzi District, and indeed all of southern Africa, are no strangers to climatic risks, and have developed some useful mechanisms to cope with them (UNDP 2009). As in other regions of Africa, southern African farmers monitor a number of indicators to predict rainfall, including plant and animal behaviours, and can adjust labour and allocate their resources accordingly (Munyua & Stilwell 2013, Zuma-Netshiukhwi et al. 2013).

Although communities are feeling the effects of climate change now, the most severe impacts will be felt in the decades to come. The use of IKS in climate change adaptation means setting climate-specific adaptation in the broader context of changing livelihoods (Kirkland 2012, Soh & Omar 2012). Understanding existing adaptation strategies used at the household and the community level is important, especially when introducing new options. Farmers are aware of the changes in their environment (Rao 2006). Whenever a bad rainfall season was anticipated, the farmers preferred to grow short-season maize varieties and small grains like sorghum. Livelihood systems shifted to focus more on market gardening and casual labour, as well as wild fruit gathering and livestock rearing (Patt & Gwata 2002). When a good rainfall season was expected, the farmers grew mostly long-season maize varieties.

The worsening climate change impact projections will require further analysis at a local level, as will evaluations of the extent to which diversification into off-farm activities could assist in building resilience. The projections, by 2030, of a 2°C increase in average temperatures and a 10% decrease in rainfall in southern Africa (Thornton et al. 2011) also suggests an increase in the frequency of crop failures. For this reason, recommending farming as a continued livelihood activity would be appropriate only for the short to medium term. This is where bringing IKS to local adaptation strategies and policies would be important. However, in the long term, a diversification of livelihoods into climate-insensitive non-agricultural activities would be a more appropriate adaptation pathway (Newsham & Thomas 2009).

Traditional coping methods are based on experience accumulated over time and transmitted from generation to generation. Prior to the 1970s, climate extremes such as strong El Niño events occurred every 10 to 20 yr. This rhythm enabled the local communities in southern Africa to deal with these problems either at the household level or through well-established social networks. Climate change is eroding these coping mechanisms by causing climatic extremes with a frequency and intensity never seen in the past. Recurrent droughts in Africa have led to the degradation of the resource base and have forced many farmers to sell their assets and migrate to cities or neighbouring countries.

However, as reported by the IPCC (2007), indigenous knowledge systems are steadily being eroded the world over and could become extinct over the next decade. When this happens, outside actors need to ensure that this traditional knowledge is preserved and protected (Kirkland 2012).

5. CONCLUSION

The role of traditional knowledge in smallholder agriculture cannot be overstated. Our research has shown that the majority of the traditional leaders and the elderly fully understand the use of indigenous knowledge in forecasting seasonal characteristics. However, even they have noticed the erosion of local knowledge. Despite this result, farmers still use indigenous knowledge to make certain coping and adaptation decisions. Climate change may bring about new sets of weather patterns and extreme events that are well beyond what the local communities are capable of dealing with. Exogenous adaptation, from non-governmental organizations and other stakeholders, is necessary to enhance social and ecological resilience among rural communities. Indigenous coping mechanisms, albeit not enough on their own to respond to climate change, can serve as a useful entry point for interventions by governments, relief organizations and development agencies. It should be noted that, despite the inclusion of indigenous knowledge in the design and implementation of sustainable development projects, little has been done to document and incorporate this into formal climate change adaptation strategies. Further research is needed to better understand the usefulness of these traditional indicators, and to see how they can be used as an entry point to operationalize science-based climate forecasting at local community levels. This will enhance resilience to climate stresses, and buttress coping and adaptation strategies.

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