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The role of indigenous knowledge (IK) in adaptation to drought by agropastoral smallholder farmers in Uganda

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Majority of agro pastoral smallholder farmers in developing countries are characterised by low pay status, high illiteracy levels and are tied to cultural beliefs and spirits. These drawbacks have led them into using more indigenous knowledge as a way of adapting to droughts. This study explored the contribution of IK in enhancing farmer's resilience to drought in crop and livestock production systems in semi-arid areas. The objectives were: (i) to examine the agro pastoral farmer's perceptions of drought indicators and associated impacts and (ii) determinants for the adoption of indigenous knowledge drought adaptation responses. Socio-economic data was collected using oral interviews. The farmers (240) were selected using random sampling procedures and subjected to structured questionnaires and key informant guides. This study highlights that the droughts experienced were perceived to be more severe, recurrent and pervasive but also erratic. The IK drought signs were: flowering of wild plants, blowing of strong winds and appearance of flying and crawling insects. In crop-based systems, droughts reduced yields, caused plant stunted growth, increased incidences of diseases and invasive weed species. In livestock, droughts reduced surface water levels, lowered milk and beef yields, and increased diseases. The farmers reacted to droughts by practicing indigenous agro forestry, mulching, changing planting time, crop rotation and hoeing of trenches to control fires and pests/diseases. They also took their animals to wetlands for foraging and drew water for animals to drink. The uptake of IK drought adaptation practices was related to: household size, personal farming life experience, gender and age of the agro pastoral farmers. Therefore, employing IK drought adaptation responses is an important step towards increasing the resilience of agro pastoral smallholder farmers but also the conservation of IK for forthcoming generations.

Keywords: Adoption, Agro pastoral smallholder farmers, Drought, Indigenous knowledge, Uganda

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Drought is associated with significant societal, economic and environmental consequences among agriculture-dependent communities[1]. The effects of drought are usually exacerbated by farmers' low levels of responsive capacity[2]. Drought mostly affects farmers located in marginal areas where there are low levels of access to adaptation technologies and high dependence on rain-fed agriculture[3].In such circumstances, farmers are kept in cyclic poverty, chronic food insecurity, migration to other areas, and in many cases, continued agitation for food aid[4].In Sub-Saharan Africa, drought occurrences coupled with the low investments in the agricultural production limit the economic performance for most of the 70-80% of the population that depends on the sector[5]. Therefore, the frequency and severity of drought occurrences remain a threat to the survival of smallholder farmers, most especially in semi-arid areas.

Transfer and adoption of indigenous knowledge-based drought responses can contribute to the resilience of crop and livestock productions[6,7]. Indigenous knowledge covers traditional and local information systems, involving social, economic and

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environmental variables, unique to a particular culture or society[8-11]. In this paper, indigenous knowledge refers to drought responses transferred, adopted and practiced by agro pastoral smallholder farmers in semi-arid areas. Drought responses have been reported to be applied according to the scale of drought indicators such as the appearance of certain birds, the mating of certain animals and flowering of some plants that are well understood in specific traditional knowledge perspective[12]. Indigenous knowledge-based drought responses may include agro forestry, mulching, fetching of water for animals and construction of harvest granaries to store food; all implemented to sustain crop and livestock production and survival[11]. The adoption of drought responses can vary depending on socio-economic variables such as the age of the farmer, gender and farming experience that determine the transfer of knowledge and its applicability[13].

Smallholder farmers in some societies adapt to harsh conditions such as drought based on community disadvantages and level of vulnerability. Indigenous knowledge is community-specific. Societies in semi-arid areas react differently to drought events than their counterparts in wet areas. This can be explained by the frequency, severity and distribution of drought events. The reactions are dependent on access and use of community assets to adapt but also a wealth of indigenous knowledge available at their exposure. Indigenous knowledge can be widely passed on to the next users through observations and hands-on practical transfer of practices. With the adoption of indigenous knowledge, many farmers have increased their resilience to extreme events and enhanced sources of livelihoods. However, it is only of recent that communities are recognizing the importance of integrating indigenous knowledge in adaptation responses to drought under smallholder farming systems. It is a topic of recognition in climate change adaptation responses.

Previous studies show that much of the documentation available on indigenous knowledge is still rooted in the domain of traditional medicine and foods[14]. Its usage in climate change responses including adaptation to drought is not widely documented, and more so, in agro pastoral based agricultural systems in semi-arid areas. Also, limited studies have made practical steps towards understanding the determinants for adoption of indigenous knowledge-based drought responses, to come-up with location-specific experiences from semi-arid areas that are known to be among the most affected by characteristic and frequent droughts. Therefore, this paper attempts to bridge this information gap to increase our understanding of indigenous knowledge in the context of acquisition, transfer and adoption of drought responses by agro pastoral smallholder farmers. This study adopted an A frocentricity theory to document the roles of IK in drought adaptation by smallholder farmers[1]. The theory illustrates that African people make sense of their everyday experiences from an indigenous African's point of view. Communities have adapted to harsh climate conditions based on cultural and society-based measures[4]. The objectives were: (i) to examine the agro pastoral farmer's perceptions of drought indicators and associated impacts and (ii) determinants for the adoption of indigenous knowledge drought adaptation responses.

Materials and methods

Description of the study area

The study area is located in the semi-arid region of Uganda. The semi-arid region usually referred to as 'cattle corridor' is characterized by relatively low rainfall distribution and settled with sparse smallholder agro pastoralists engaged in both livestock and crop production (Fig. 1). Out of over 20 districts approximately covering the dry belt, three districts were purposely selected for this study: Ntungamo, Kamuli and Sembabule. The study districts generally experience a bi-modal type of rainfall with rainy seasons occurring in March -June and August- November periods of each year. The annual average rainfall received is about 1,350 mm while the mean monthly temperature ranges from 19°C to 36°C. However, this amount of rainfall received is unreliable and unevenly distributed across the semiarid region. Drought occurrences impacted farmers through reduced yields and water scarcities[2]. They have specifically led to crop failure, human and livestock mortality among others[5]. The dominant vegetation types include grasslands, bushlands, thickets, woodlands and wetlands (both permanent and seasonal). The region is generally flat with gently sloping hills prominent in Sembabule and Kamuli districts while Ntungamu is largely hilly with steep slopes. Kamuli District is situated on Petric Plinthosol soil type while Ntungamu and Semabubule districts are endowed with Acrylicferralsols that facilitate

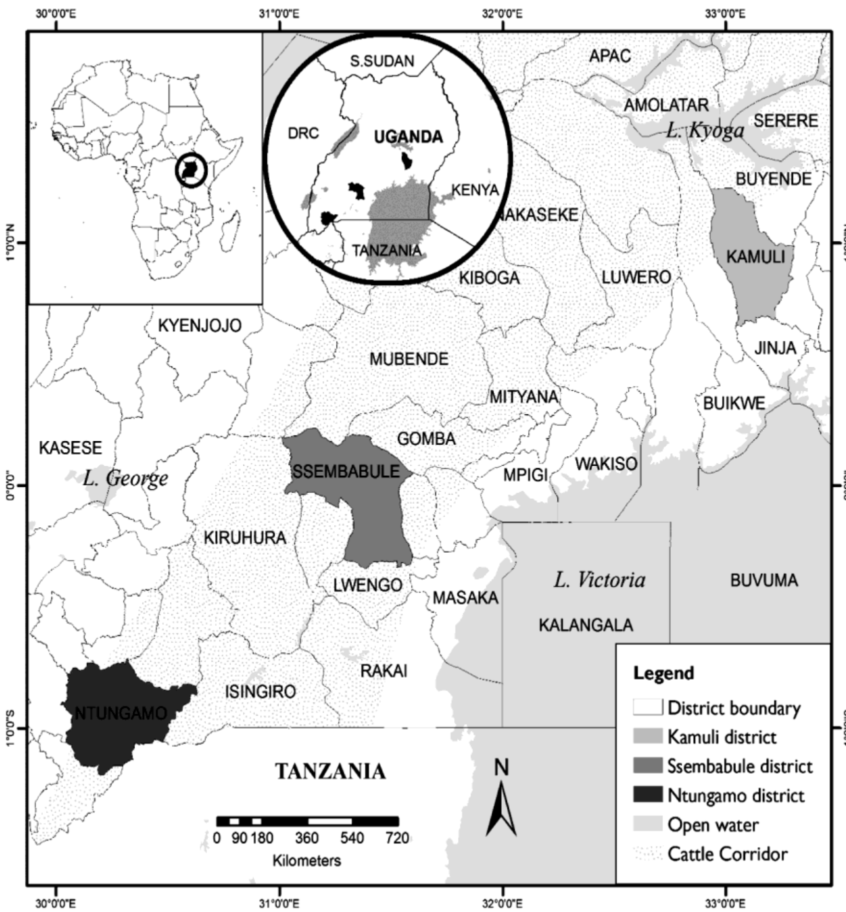

Fig. 1 — Location of study area

smallholder livestock and crop production. The major economic activities are crop production and livestock keeping. The main food and cash crops grown in the region include banana, maize, coffee, cassava, sorghum, Irish potatoes, beans, vegetables among others, whereas the most reared livestock include cattle, pigs, goats, poultry and sheep among others.

Scope of indigenous knowledge

In the study area, indigenous knowledge is widely used and dates back to historical times. IK adoption and usage are related to how farmers planted crops, pruned and conducted post-harvest interventions to drought adaptation. There is a clear distinction between IK and planned crop-based activities and these are easily differentiated on observations, course of actions and outputs. However, given the changing climate, IK is constrained by unpredictable changes in the frequency and severity of extreme events. For instance, from historical times, farmers still use indigenous seeds for planting and animals because these have high adaptability to the conditions of the local environment. The success stories of employing IK in smallholder farming systems has improved the resilience of farmers to extreme events. Therefore, any planned technological improvements in the smallholder farming systems should base on the already set foundation of IK achievements.

Data collection and analysis

Design and sampling procedures

A household survey methodology was adopted by this analysis because of its strengths in obtaining socio-economic data from household to community levels. A cross-sectional research strategy was used to select agropastoral farmers included in this investigation. It was assumed that all the interviewed agropastoral smallholder farmers were engaged in crop and livestock production and used indigenous knowledge-based drought responses in their seasonal farming activities. In each selected district, a four-phased multi-stage sampling framework was adopted to select the study sample based on the administrative boundaries generated by the Uganda Bureau of Statistics for the year 2016. The first stage was based on district boundaries, the second stage on sub-counties, while the parishes and villages were the basis for the third and fourth stages respectively. Before going to any parish or village, the key informants were purposively selected at the district and sub-county levels for opinions that helped in more understanding of the study area, using interview guides on drought responses based on indigenous knowledge. At the village level, each selected agro pastoral farmer was administered with a pre-tested and validated household survey structured questionnaire. The questions asked revolved around the indicators of drought, perceived impacts of drought and determinants for adoption of indigenous knowledge. Nationally, the adopted study design was prudent in sampling smallholder farmers and the type of questions asked was sufficient to collect relevant information on the farmers household characteristics and tract their use of indigenous knowledge. The smallholder farmer perceptions were examined and ranked depending on the severity of droughts. The data was collected using open-ended questions for detailed investigation. The questions were rooted from a detailed understanding of drought occurrences in the study area and its associated impacts. This information was obtained through literature review and consultations.

In each district, two sub counties were selected on the advice of key informants. In the sub counties, 3 parishes were selected and in those parishes, 4 villages were sampled where 20 respondents were orally interviewed. At village level, a membership list was obtained and used to randomly select the respondents on the guidance of community leaders. A total of 240 agro pastoral smallholder farmers were selected and interviewed within their home vicinities. The household heads were the target and these were sampled and interviewed in question and answer sessions. Secondly, 2 focus group discussions were conducted at sub county level – were the participants (15) were convened at a convenient meeting place (sub county office) for discussions. The members were gathered purposively on the advice of the village leaders depending on the farmer’s farming experience, understanding and employing IK in farming systems. Information from the discussions was recorded on flips and transformed into reports. Additionally, key informants were interviewed at the district levels. These were purposively selected by the administrative officers because of their detailed understanding and experiences with smallholder farmers. The selected members included agricultural officer, education officer, environment officer and water officers. The focus group participants were composed of youths, females and males to obtain representative responses.

Data analysis

Data collected with questionnaires was coded, entered and analyzed to establish the drought responses, modes of acquisition and transfer of indigenous knowledge and its adoption. The analysis was performed using STATA version 13 statistical software. A Multinomial Logistic Model (MNL) was used to examine the determinants of the adoption of drought responses based on indigenous knowledge. The drought responses included in the regression model were mulching, indigenous agro forestry, crop rotation and changing planting time (early/delayed planting). The model was developed to assess the determinants of adoption of drought responses in smallholder production. The socio-economic factors investigated included household member size, membership to farmer groups, the age of household head, personal life experience, land size, access to credit, gender status, formal education and household income.

The logistic model for this study was; $Y_i = \text{In} (P_i/ 1\text{-}P_i) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + e_i$

Dependent variables:

Where; P_i = probability that a household would respond by using any of the drought responses

$(1\text{-}P_i)$= probability that the household does not respond

The explanatory variables were; X_i, where i = 1, 2,…..9Where;

X_1= age of household head

X_2 = education level of household head

X_3 = household size

X_4 =income of household head

X_5 = gender

X_6 = membership to farmer groups

X_7 = access to credit

X_8 = land size

X_9 = personal life experience

Results

Agropastoral smallholder farmer's perceptions of drought indicators and associated impacts

The farmers perceived drought as prolonged conditions of intensive sunshine above normal, causing scarcity of forage and water. A large percentage of smallholder farmers indicated that the frequency of drought occurrences had increased, while a few of the farmers did not notice any changes in drought. Most of the farmers reported that the droughts had become severe and disastrous to their agricultural production efforts. From the focus group discussions, the duration and extent of drought occurrences were reported to have increased for the last 30 years. Based on experience, indigenous knowledge, the farmers revealed an increment in crop failure of planted crops, water scarcity and drying of grazing lands. The farmers also indicated that the droughts lasted between 4 to 6 months as compared to 2 months in the past 15 years back in time (Table 1).

Impacts of drought on crop and livestock production

The drought was reported by respondents to have caused stunted crop growth, crop failures and reduced harvests. An increase in crop pests (such as armyworms) and other crop disease burdens, and the introduction of invasive weeds such as Striga weed were also attributed to worsening drought conditions. The farmers perceived drought to have reduced soil productivity on their land resulting in food shortages. Forty percent of the farmers reported loss of forage and reduced water availability for livestock as a result of frequent drought occurrences (Table 2).

Indigenous knowledge-based indicators of drought

The main indigenous knowledge-based indicators of drought used by the farmers included flowering of wild plants, the appearance of flying and crawling insects and strong winds. The other indicators were a sudden and consistent increase in surface temperatures, frequent appearances of mist in the morning, the ripening of fruits, flocking of birds and shedding of tree leaves such as *Milicia excelsa* (Table 3).

Indigenous knowledge acquisition and transfer

Table 4 below reveals that indigenous knowledge-based indicators of and responses to drought were majorly transferred amongst the farmers through direct observations, community and local law enforcement, observation of traditional beliefs, performance of cultural rituals and traditional

Table 1 — Perceptions on drought frequency, severity and duration

Drought occurrences	Percentage
Frequency	
More frequent	88
No change	11
Less frequent	1
Severity	
Highly Severe	85
No change	15
Duration	
Longer	76
Shorter	17
No change	7

Table 2 — Impacts of drought on crop and livestock production

Impacts	Percentage
Crop production	
Stunted crop growth	35
Loss of crop yields	23
Increased incidences of pests and diseases	20
Introduction of invasive weeds	15
Reduced soil productivity	7
Livestock production	
Forage and water shortages	40
Low milk yield	23
Loss of weight and beef quality and quantity	13
Parasites and diseases	16
Increased deaths of livestock	8

Table 3 — Indigenous knowledge-based indicators of drought

Indicators/signs	Percentage
Drought	
Flowering of wild plants	34
Appearance of flying and crawling insects	25
Blowing of strong wind	20
Changes in surface temperatures	11
Mist appearances	5
Ripening of fruits	2
Flocking of birds	2
Shedding of tree leaves	1

Table 4 — Modes of indigenous knowledge acquisition and transfer

Modes	Percentage
Personal direct observations	41
Community and local law enforcement	17
Observation of traditional beliefs (cultural taboos)	14
Performance of cultural rituals	13
Traditional storytelling	11
Traditional songs	3

storytelling. The findings show that the community observance of cultural values and traditions were key in the sharing of indigenous knowledge amongst the agropastoral farmers.

Indigenous knowledge-based drought adaption responses

The majority of the households responded to drought effects indigenously by practicing mulching, undertaking agroforestry and changing of crop planting time to sustain production. The remaining smaller portion of farmers responded by practicing crop rotation, application of organic manure, construction of granaries to store harvests, digging of trenches in farmlands to control the spread of pests and diseases such as banana weevils (Table 5 and Fig. 2-5). The soil and water-related indigenous practices were the most adopted by farmers to in responding to drought. The farmers also highly adopted more of on-farm drought responses compared to off-farm practices such as the construction of granaries.In response to drought under livestock production, the majority of the agro pastoral smallholder farmers moved with their animals to the nearby wetlands for grazing followed by those who

Table 5 — Indigenous knowledge-based responses to drought

Practices	Percentage of respondents
Crop production	
Mulching	26
Indigenous agroforestry	22
Change of planting time	20
Crop rotation	15
Digging of trenches	10
Application of organic manure	4
Construction of granaries	3
Livestock production	
Grazing animal in wetlands	54
Fetching water for livestock drinking	24
Taking animals to nearby rivers, ponds, dams to drink	16
Tying animals under tree sheds	6

Fig. 2 — Mulched banana plantations

Fig. 3 — Traditional granary used to store harvest

Fig. 4 — Local and indigenous agro forestry

Fig. 5 — Trenches dug to control pests and diseases

fetched water for livestock drinking. The farmers also indicated that they moved with their animals to nearby water sources such as rivers, boreholes, dams and ponds for water. Searching for water and forage were the most common traditional responses applied by nearly all the agro pastoral farmers. Comparatively, the agro pastoral farmers adopted a wider scope of crop-based drought adaptation responses more than for livestock production.

Determinants for the adoption of indigenous knowledge drought adaptation responses

Table 6 shows that household size, personal farming life experience, gender and age of the agro pastoral farmers were the major determinants for the adoption of indigenous knowledge-based drought adaptation responses in smallholder production. The results show that for an additional year of age of the household head, a smallholder farmer is more likely to adopt indigenous knowledge-based responses to drought adaptation in both crop and livestock production. Farmers who had limited personal life experience with droughts were less likely to undertake indigenous knowledge-based agro forestry. For every additional family member, the higher the likelihood of adoption of indigenous knowledge-based responses to drought adaptation. Access to credit facilities, formal education level and membership to farmer groups were not significant determinants of farmer's adoption of indigenous knowledge-based responses to drought of any of the identified practices.

Discussion

The findings of this study are an important step towards advocating for further documentation and dissemination of indigenous knowledge. This section is premised on the key findings that were observed. The experienced droughts were reported by the agro pastoral farmers to be severe and more frequent but also unpredictable[3]. The shifts in seasons raises more questions on the effectiveness of IK on their belief and perceptions on drought occurrences, durations and impacts. These conditions have exposed the planted crops and reared animals to uncertainties of drought.

This study also revealed that the smallholder farmers employed IK to forecast short term droughts. The forecasts were based on the visibility of flowering of wild plants, blowing of strong winds and appearances of flying and crawling insects. Most of these indicators of drought are related to changes in the natural environment, such as phenological changes in plants and animal behaviour[15,16]. Phenological indicators of seasons based on indigenous knowledge were also reported by Orlove *et al.*, 2010 in a study that showed that flowering of trees, especially coffee trees are signs used to forecast the occurrence of rains received in a few weeks[17]. Similar findings were also observed by Singh & Singh, 2011 that the *Capparis decidua* (Forsk.) Edgew plant’s unique capacity to tolerate drought and heat makes it a good weather forecasting species, which has plays an important role in the rural economy of western Rajasthan and Gujarat in India[6]. Therefore, the protection of indigenous tree species is important in the conservation of indigenous knowledge. If the wild plants are totally depleted, then this will have a significant bearing on the transfer of the knowledge to the next generations.

Because of shifts in seasons, the drought indicators sometimes did not well represent the intensity and

Table 6 — Adoption and use of indigenous knowledge-based responses to drought in crop and livestock production

Factors	Mulching		Indigenous Agroforestry		Crop rotation		Early/delayed planting	
	Coef.	P>z	Coef.	P>z	Coef.	P>z	Coef.	P>z
Age of household	0.07	0.02	-0.06	0.03	0.02	0.52	0.02	0.40
Formal education level	1.35	0.21	0.76	0.48	-17.01	0.99	1.71	0.09
Households size	-0.05	0.04	0.06	0.04	-0.12	0.22	0.03	0.39
Household income level	0.00	0.06	0.00	0.35	0.00	0.84	0.00	0.96
Personal life experience	1.80	0.03	-1.52	0.05	0.87	0.31	-1.06	0.23
Membership to farmer groups	0.56	0.45	0.85	0.26	0.05	0.94	1.75	0.04
Access to credit facilities	-0.43	0.56	-0.61	0.42	-0.21	0.80	-1.15	0.11
Household land size	-0.34	0.04	0.25	0.11	0.18	0.30	-0.33	0.05
Gender	-2.55	0.02	1.31	0.22	-0.24	0.83	0.23	0.80
Const.	-2.47	0.22	3.20	0.03	1.16	0.45	-0.49	0.72
Prob>chi^2	0.0015		0.04		0.2935		0.4638	
Pseudo R^2	0.2856		0.367		0.245		0.1299	

severity of upcoming events to be experienced. This is still a challenge. Luseno *et al.*, 2003 and Masinde & Bagula also, 2011 asserted that besides these limitations the use of indigenous knowledge drought indicators can improve the value of modern seasonal forecasts for smallholder farmers found in drylands[18,19]. This research further argues that the farmers should widely share and deploy IK drought adaptation responses for its sustainability but also the farmers should be more observant of changes in the components of surrounding environment given the fact the farmers are leaving in a changing climate.

In response to recurrent droughts, most agro pastoral farmers responded by mulching gardens, practicing indigenous agro forestry, changing planting time, crop rotation and digging of trenches to control fires and diseases. They also took their animals to wetlands for grazing and fetched water for animal drinking. With these meaningful interventions, this study reveals that the adopted IK based drought adaptation practices to drought should be conserved and shared if it's to be shared from one generation to the other. Between crop and livestock productions systems, the crop-based IK drought adaptation interventions are the most implemented compared to those that are livestock grounded. However, most of these measures are thought to be long-term in nature with no quick outputs. The disadvantage of this scenario is that it has rendered most farmers to be food insecure.

This study also shows that the implemented IK drought adaptation measures were dependent on a number of factors such as household size, personal farming life experience, gender and age of the agropastoral farmers. One of the reasons for household size is due to the fact that agro pastoral smallholder activities are heavily dependent on family labour. The more the size of the household membership the more sharing and wider application of IK drought adaptation responses in crop and livestock production. The results also show that a farmer growing up in the study area and with active engagement in the farming activities highly influenced the uptake of IK drought adaptation actions. The male farmers were fast adopter because of involvement in many social meetings/ gatherings that existed in society from rearing to farming and social farming groups. The female farmers played more gender roles at home. Jha & Jha[3]also observed that since tribal groups have lived within their local environments since time immemorial it is obvious that they do possess a rich knowledge about nature. Lastly, the more smallholder farmers were experienced in crop and animal farming system the more they would adopt the IK drought adaptation responses. Rugumayo & Mwebaze, 2002 also observed that the adoption of drought responses can be dependent on socio-economic variables such as the age of the farmer, gender and farming experience[20]. In a scenario of gender roles, it greatly means that women smallholder farmers are left out from obtaining IK.

Despite the implementation of IK drought adaptation responses, smallholder farmers still face many challenges. In crop-based systems, droughts continue to reduce yields, cause plant stunted growth, increase incidences of diseases and invasive weed species. And in livestock systems, droughts reduce surface water levels, lower milk and beef yield, and also increase diseases. The reoccurrences of these effects reduce the farmer's dependency entirely on the use of indigenous seeds and animals reared and some now opt for improved varieties that are fast-growing, drought resistant and high yielding. In the long run, farmers are exposed to malnutrition, low levels of incomes and seeking for food aid. Similar findings were also made by Singh & Pandey[9] that poor farmers are more likely to diversify to drought-resistant varieties in times of droughts than their counterparts.

Conclusion

This study highlights that the droughts experienced were perceived to be severe and frequent but also unpredictable. The observed signs of droughts were: flowering of wild plants, blowing of strong wind and appearance of flying and crawling insects. Depending on the intensity and severity of drought, the impacts varied between crop and livestock production. In crop-based systems, droughts reduced yields, caused plant stunted growth, increased incidences of diseases and invasive weed species. In livestock, droughts reduced surface water levels, lowered milk and beef yield, and increased diseases. With these effects, the agro pastoral farmers indigenously deployed mulching of their gardens, practiced indigenous agro forestry, changed planting time, applied crop rotation and digging of trenches to limit fires and spread of diseases. Overall, the findings of this study reveals that IK based drought adaptation measures should be embedded into the educational curriculums of farmer school as steps being taken to practically help farmers learn how to adapt to droughts and if possible, in schools for sustainability. This can be achieved with the support of policymakers and continuous research by scientists in the arena of indigenous knowledge. This study shows that indigenous drought indicators should be incorporated into future climate forecasts to recognize the importance of this wealth of knowledge and information. This study is also a step towards characterizing indigenous climate change indicators and their strength worldwide as per the different climates.

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