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Effect of drought early warning system on household food security in Karamoja subregion, Uganda

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Abstract

Background: Drought is regarded as a leading cause of food insecurity affecting about 220 million people in sub-Saharan Africa. Drought early warning systems (DEWSs) have the potential to strengthen capacity of communities in managing and reducing drought effects through building preparedness and providing coping strategies. The Karamoja subregion is the only region with a functional DEWS in Uganda. The subregion suffers from effects of recurrent episodes of drought with negative impacts on food security. Despite having DEWS in place, the subregion remains the most food insecure in the country. The extent to which DEWS has contributed to household food security in the subregion remains unclear. This study determined the effect of DEWS on agro-pastoral household food security in the subregion. The study was conducted in Nakapiripirit and Kotido districts of the Karamoja. A cross-sectional survey was conducted among 305 participating and non-participating households in DEWS. The effect of participating in DEWS on food security was analyzed using the generalized linear model. The level of food security and nutrition were measured using the household food insecurity access score and household dietary diversity score (HDDS), respectively.

Results: Findings showed that all respondents had experienced food insecurity during the course of the year. Drought was indicated as the main cause of food insecurity in the households. Participation in DEWS significantly ($p < 0.01$) reduced the threat of food insecurity by 23.7% and increased the level of household nutrition by 30%. Better nutrition was realized in DEWS participating households (HDDS = 9.0) compared to non-participating households (HDDS = 6.6).

Conclusion: Owing to intermittent drought events in the Karamoja subregion, DEWS contributes to household food security and nutrition by providing households with information on timely planting, crop diversification, farm equipment, drought management and drought-tolerant crop varieties. There is need for DEWS practitioners to focus on information dissemination, provision of drought-tolerant crops and provision of training opportunities to communities for increased production in semi-arid areas.

Keywords: Drought early warning system, Household food insecurity access scale, Dietary diversity score, Karamoja subregion

Background

Drought is regarded as the leading cause of food insecurity in sub-Saharan Africa (SSA) since the region depends on rain-fed agricultural production [1–3]. This is in addition to other underlying causes that relate to factors which maintain high levels of poverty and vulnerability [4, 5]. Drought undermines farm yields and national harvests by reducing household and national food availability, and agricultural income that is derived from crop and livestock sales [6]. Poor harvests threaten food security and livelihoods at both household and national level as per dependence regime on agriculture for its food and income. Failed food production in any period of year constrains the ability of resource-poor households to access

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and afford food as physical scarcity and food prices often rise [6]. Further, interruptions in food supplies often triggers nutritional challenges especially among resource-poor households that already constrained and marginally performing in terms of nutritional quality [6]. In pastoral and agro-pastoral regions that are heavily dependent on livestock, drought events have incrementally caused devastating effects on livestock performance in terms of its ability to provide a constant supply livestock products that are essential for household food security.

Sub-Africa's food security situation is worrying with over 220 million people being food insecure [7] and one in every four people being undernourished [7], a reversal of this situation is an important necessity. The dire food insecurity in SSA is mainly attributed to the drought as over 80% of the food insecurity in the region occurs in drought prone regions in eastern, southern and west Africa. These locations are also part of the major SSA marginal dry land ecosystems with considerably high levels of poverty, conflict and other intricately associated natural hazards including crop and livestock pests and diseases [7]. Intermittent occurrence of drought events in these regions further exacerbates these underlying causes of food insecurity in SSA, especially among the pastoral and agro-pastoral communities [8, 9].

In the dry land ecosystems of SSA, pastoral and agro-pastoral communities have traditionally coped with drought utilizing robust traditional early warning systems based on nature signals such as patterns of vegetation, stars, moon shapes and insect movement patterns [10, 11]. The communities recognize unique situations associated with the behavior of the animals, birds and insects and the locations and patterns of cloud, winds, the moon and stars and relate these to specific drought hazards. The predictions based on these indicators and human feelings supported the early warnings issued by the elders to enable the community cope with the anticipated natural hazard [11]. However, the rapid changes and altered patterns of drought in the region associated with climate variability and extreme change in events has challenged these traditional systems. Better systems that can relay information to wider audiences, to pastoral and agro-pastoral communities were urgently needed to mitigate this anomaly, like elsewhere in the world are required within SSA. Accordingly, the international community supported the introduction of contemporary robust drought early warning systems in SSA in response to persistent drought episodes that severely affected food security in the region.

Drought early warning system (DEWS) represents one of the available options for reducing and managing the effects of drought worldwide. One of the core objectives of the DEWS is to provide information that enables communities to cope with food insecurity situations through encouraging food storage, saving resources for food purchases during food scarcity and planting early maturing crops [12, 13]. The system involves collection, analyses and dissemination of information that is related to vulnerability and risks of drought. The system also prepares the households to cope with the effects of drought [14–18].

Intermittent and debilitating drought episodes in the Uganda's "cattle corridor" especially in the Karamoja subregion since the 1920s [19] have subjected the subregion into periodic crop production failure and livestock loss and subsequent food insecurity [2]. A climax to this situation was reached in 1964 with the introduction food relief [20, 21]; food aid has since then not left the subregion. By 2009, the general food distribution peaked with 1.15 million individuals, an estimated 90% of the entire population receiving food relief [2]. These events led to calls for urgent intervention by government and development partners to strategically develop mechanisms that will facilitate communities in the region to appropriately respond to drought episodes. This led to the implementation of the DEWS in Karamoja subregion as one of the strategic interventions by both state and non-state actors. This action made Karamoja the only region with a functional drought early warning system. Despite implementation of DEWS, the current food security status in Uganda indicates that Karamoja remains the most food insecure with 50% of the population affected [8] compared to the national average at 26% [7].

The functionality of DEWS to contribute to timely response to drought and food security is driven by timely generation and dissemination of information, and the ability of the household to appropriately implement the coping strategies. Decisions on drought management and response are dictated by social–economic and ecological components of society. Several researchers have previously indicated that timely response to drought is influenced by socio-ecological dispositions including arable land ownership, distance to water source, access to information from drought early warning systems and training on drought management [12, 23]. Social contexts are critical in pastoral and agro-pastoral societies such as those in Karamoja subregion in influencing perception and adoption as well as technology and information use. This is because pastoral communities are highly socially niched [11]. Accordingly, providing information in these areas is one thing, and use and success is another. This raises the question to the extent the DEWS that was established in Karamoja in 2007 has performed over time with respect to reducing food insecurity. In this respect, this study determined whether DEWS contributes to the food security in Karamoja subregion. The study provides empirical evidence on the relationship between DEWS

information and household food security. It also provides evidence on whether or not DEWS has any statistically significant effect on household food security and nutrition. The study was guided by the following questions: (1) What changes have occurred in the households that are accessing and utilizing information from the DEWS? And (2) to what extent is DEWS associated with household food security?

Research methods

Description of study area

This study was conducted in the Karamoja subregion in the districts of Nakapiripirit and Kotido (Fig. 1). The subregion intensely experiences climate variability owing to its semiarid conditions. [10] Annual rainfall in the region varies from around 400–1000 mm depending on location. Meanwhile, mean temperature ranges from 16 to 24 °C. Owing to intense rainfall variability and high evapotranspiration in the region, intermittent drought episodes have become characteristic in the subregion [23].

The DEWS implementation was first piloted in the two districts of Kotido and Nakapiripirit. These two districts have a predominance of agro-pastoralism as the main subsistence production practice. Kotido subsists in the central sorghum and livestock zone while Nakapiripirit lies in the western mixed crop-farming zones; these are the two predominant zones in the Karamoja subregion [25]. The population statistics of Nakapiripirit and Kotido districts are 69,691 and 178,909, respectively [22]. A mixture of cereals and legumes are grown including some pulses such as sorghum, pearl millet, maize, groundnuts and sunflower. Meanwhile, livestock breeds such as sheep, goats, sheep and camels are kept.

Data collection

A cross-sectional survey was conducted in 2014 from purposively selected sub-counties based on the DEWS

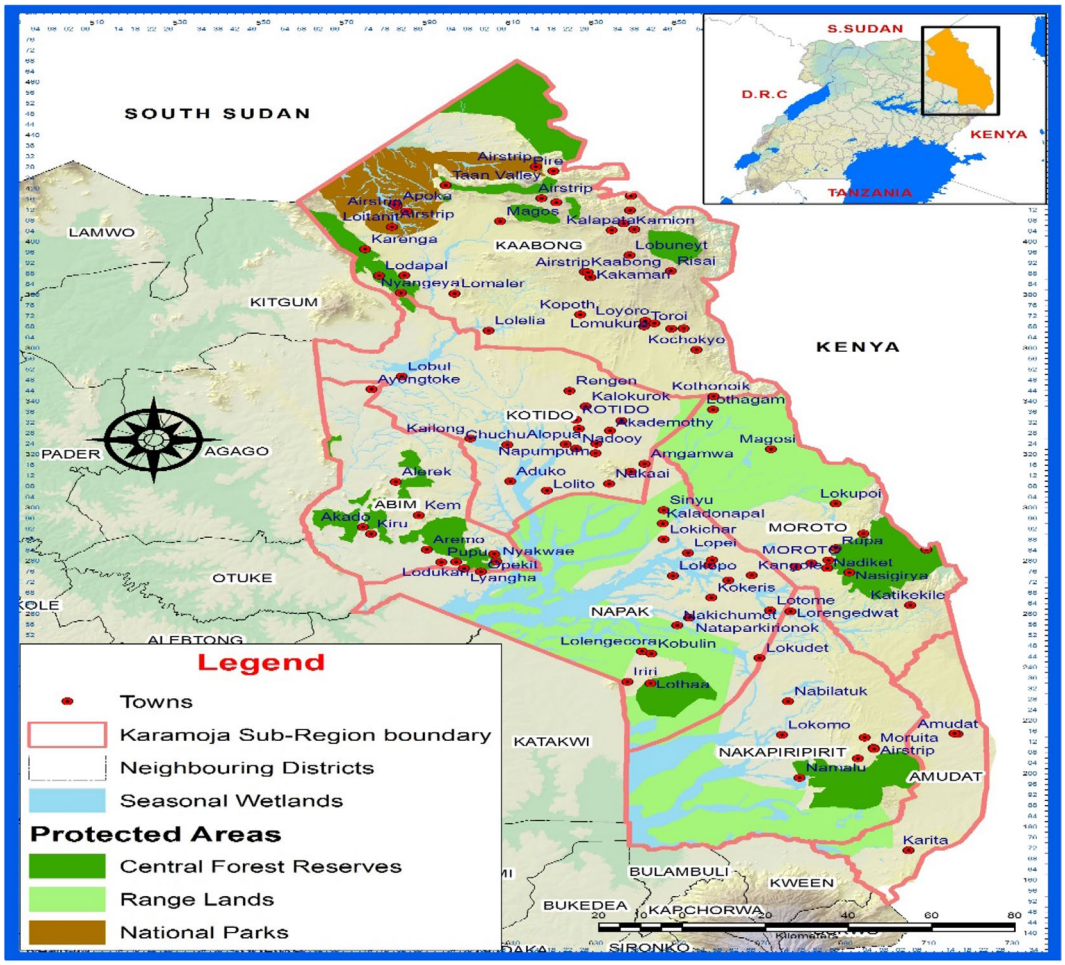

Fig. 1 Map of Karamoja subregion showing the study area

coverage. A multistage sampling criterion was used sequentially across two hierarchical levels. At the first level, sub-counties were purposively selected from each district based on the DEWS project selection criteria. At the second level, three to four parishes were purposively selected from each sub-county based on project coverage. Three participating parishes and non-participating parishes were selected from each sub-county. This amounted to a total of four parishes per district from which household respondents were purposively selected. All the parishes covered by the DEWS were considered for the study. Of the selected households, 173 participating and 132 non-participating households were used in the survey. One hundred and seventy-three (173) households were considered in order to ensure a total coverage of all DEWS participating households in the two project districts. While the sample size for the control households was initially the equivalent of the DEWS participating households included in the study, the number reduced because during the process of data cleaning, some households were dropped.

The study used guided semi-structured questionnaires to collect data. Guided questionnaires were used because of high illiteracy rates in the study communities at 90 and 83% for Kotido and Nakapiripirit districts, respectively [22]. Under such conditions, it is inconceivable to undertake self-administered questionnaires in data collection as the response rate and data quality would be extremely low. Data were collected by research assistants who knew the local language (Karamojong). Information and records of government and non-government reports were also reviewed from the national archives in Entebbe, Makerere University, Meteorology Department, in the Ministry of Water and Environment and other government departments. During data collection, the interviewers were able to make direct field observations on crop and livestock management practices at household level.

In this study, a household was taken as "the basic unit of society involved in production, reproduction, consumption and socialization" [26]. This meant that household members share a residence and meals, and make coordinated decisions, resource allocation and income pooling in some cases [26]. In addition, they recognize the authority of a single head of the household in major decisions relating to drought preparedness and response actions. Data captured were on the wider and specific social contexts of food security and DEWS information utilization at household level. Further, within the semi-structured questionnaire, the nine questions that helped in the construction of the household food insecurity access scale (HFIAS) model included: (1) worrying about getting enough food; (2) actual failure to get enough food; (3) eating poor quality foods; (4) relying on a few kinds of foods; (5) reducing the amounts of food eaten; (6) skipping meals; (7) eating less than what one feels they should have eaten; (8) not eating for a whole day because of lack of food; and (9) growing thinner because of not eating enough food were embedded in the instrument. These questions were asked based on a dummy approach with the respondents expected to either say yes or no. In this case, the responses were used to generate the raw food security scores ranging between 0 and 9 points with 0 representing the most food secure households while 9 indicates an extremely food insecure household [27, 28]. Attribution of DEWS to food security was determined by a comparison between the type of household herein called DEWS household and control household who did not participate in the DEWS intervention.

Similarly, in developing a link between DEWS and food security, the survey questionnaire contained a component of dietary diversity assessment [29]. Dietary diversity is a qualitative measure of food consumption reflecting the households' access to a variety of foods. It is a proxy of nutrition adequacy. Dietary diversity also reflects a snapshot of the economic ability of a household to consume a balanced diet. Respondents were asked to score on the food items they consumed in the last 24 h. The food items included cereals, vitamin-rich vegetables, roots and tubers, dark leafy vegetables, other vegetables; vitamin A fruits; other fruits; meat, poultry, offal; eggs; fish; pulses/groundnuts/legumes; milk and milk products; oil/fats; sugar/honey. The expected response was either yes = 1 or no = 0 following Kefasi Nyikahadzoi [29] method.

Data analysis

Determination of dietary diversity

The household dietary diversity score (HDDS) was calculated as: $HDDS\ (0–14) = Sum\ (A + B + C + D + E + F + G + H + I + J + K + L + M + N$, reflecting the total number of food groups consumed by members), where A = cereals; B = vitamin-rich vegetables; C = roots and tubers; D = leafy vegetables; E = other vegetables; F = vitamin A fruits; G = other fruits; H = meat, poultry, offal; I = eggs; J = fish; K = pulses/groundnuts/legumes; L = milk and milk products; M = oil/fats; N = sugar/honey. The results of analysis of the HDDS were to support the HFIAS model to determine the food security status of the household. For this study, all the vegetables were merged as one food item, and all the fruits were merged as one, making a total of 12 food items. This was because the vegetables eaten in Karamoja were mainly wild vegetables (there were no domesticated vegetable varieties) to be categorized as leafy vegetables and other vegetables. The same was true in fruits. People mostly ate wild fruits.

Descriptive and econometric methods were used to analyze the data. Descriptive analysis involved generating means, percentages and correlations. A generalized linear model was used to determine which factors influence food security and dietary diversity. Dietary diversity is a qualitative measure of food consumption that reflects household access to a variety of foods, and is also a proxy for nutrient adequacy of the diet taken. Household dietary diversity scores (HDDSs) were used as a measure of household nutrition security [30].

Effects of drought early warning systems on food security

A generalized linear model (GLM) was used to determine the factors in household food security outcome, with proportion of HDDS on a range of 12 as the dependent variable. The model assumed a relationship between observations y of the random response variable Y and a probability (density) function [31]. The GLM supports in the development of a strategy for approaching statistical problems that involve non-normally distributed data, in a way that retains much of the simplicity of linear models. The model used the assumption of exchangeability in that if Y is the dependent variable, Xs are explanatory variables, i.e.,

$$Y \equiv Y[U] = Y(u_1), \ldots, Y(u_i) \text{ on sample units and}$$
$$X \equiv X[U] = X(u_1), \ldots, X(u_i).$$

Assuming exchangeability, $X[U] = X\left[U'\right]$ implies for all $U, U' \subset U$.

The GLM also assumes independence of error terms of the various sampling units in a way that $Y(u_1), \ldots, Y(u_n)$ are independent. The Y and the error term tend to a normal distribution so that $Y \sim N\left(\mu = X\beta, \delta^2 ln\right)$, $E(Y(U)) = \beta_1 X_1 + \cdots + \beta_p X_p(u)$ [32].

The model was therefore specified as in Eq. (1) and estimated as in Eq. (2).

$$Y = \beta_0 + \beta_i X_i + \cdots + \mu \tag{1}$$

$$HDDS = \beta_0 + \beta 1_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_{28} + \beta_9 X_9 + \varepsilon_i \tag{2}$$

where *HDDS* is the proportion score of a household on the household dietary diversity score scale, *X1* is gender of the respondent, *X2* whether or not the respondent has participated in DEWS intervention, *X*3 is age of the respondent, *X4* is the educational level of the household head, *X5* is the distance to the water source, *X6* is the total land owned by the household, *X7* is the land utilized by the respondent, *X8* is the household labor and *X9* is the distance to the local trading center and ε is the error term.

The GLM was also used to determine the factors affecting household food security outcomes, with proportion of the household food insecurity access scale (HFIAS) score as the dependent variable and independent variables as in Eq. (2).

A multi-collinearity test was done to check for associations among continuous variables and discrete variables which seriously affect the parameter estimates. As Gujarati [33] indicates, multi-collinearity refers to a situation where it becomes difficult to identify the separate effect of independent variables on the dependent variable due to existing strong relationship among them. In other words, multi-collinearity is a situation where explanatory variables are highly correlated. There are two measures that are often suggested to test the existence of multi-collinearity. These are variance inflation factor (VIF) for association among the continuous explanatory variables and contingency coefficients (CC) for dummy variables. In this study, both VIF and CC were used to check multi-collinearity of continuous variables. The computerized Statistical Package for Social Scientists (SPSS), version 18, was used to compute both VIF and CC. The results from multi-collinearity test show that there is multi-collinearity between the use of the DEWS information and households who were participating in DEWS intervention. A variance inflation factor (VIF) greater than 2 is usually considered problematic and there were two variables in the model with VIF more than 3 indicating possible effect of multi-collinearity between the variables. Therefore, the use of DEWS information was dropped from the model.

Results

Household characteristics

Most of the households (87%) were engaged in farming, and 98% of these households were male headed, married and polygamous (Table 1). Only 1.5% of the households earned a salaried income as part of a non-farm income. Over 94% of respondents lived in mud and grass thatched houses. The average household size was 10 members. Majority of the respondents and household heads had an average three years in school, while the women had no education at all. The results further indicated that there were more households under DEWS with school-going children (79%) compared to the control households with 63%.

Land ownership

The average total land owned by non-participating households was 4.72 acres with standard deviation of 4.82 and that of participating households was 7.19 acres

Table 1 Socio-demographic characteristics of households in the Karamoja subregion

Characteristics	Non-participating households			Participating households		
	Pooled (*N* = 132)	Kotido (*N* = 65)	Nakapiripirit (*N* = 67)	Pooled (*N* = 173)	Kotido (*N* = 86)	Nakapiripirit (*N* = 87)
Gender of respondent (% female)	62.9	69.2	56.7	59.5	62.0	56.8
Gender of H/H (% males)	98.5	96.9	100.0	94.8	93.5	96.3
Marital status						
Married	83.3	83.1	83.6	88.4	88.0	88.9
Divorced	0.8	0.0	1.5	1.2	1.1	1.2
Widowed	15.2	15.4	14.9	10.4	10.9	9.9
Single	0.8	1.5	0.0	0.0	0.0	0.0
Occupation						
Farming	87.9	90.8	85.1	85.0	89.1	80.2
Salaried income	1.5	1.5	1.5	4.6	5.4	3.7
Self-employment off farm	1.5	1.5	1.5	1.2	1.1	1.2
Farmer worker	1.5	0.0	3.0	2.3	0.0	4.9
Causal labor	3.8	0.0	7.5	2.3	3.7	1.1
Housekeeping	0.8	0.0	1.5	0.6	0.0	1.2
Schooling	2.3	4.6	0.0	2.9	3.3	2.5
Household with children going to school (% yes)	63.6	67.2	60.0	79.2	80.2	78.3
Type of house						
Mud wall, grass thatched	94.7	90.8	98.5	78.0	65.2	92.6
Brick wall, grass roofed	2.3	3.1	1.5	9.2	16.3	1.2
Mud wall, iron roofed	1.5	3.1	0.0	6.9	10.9	2.5
Brick wall, iron roof	1.5	1.5	0.0	5.8	7.6	3.7

with standard deviation of 12.09 (Table 2). The average total land used by the DEWS participating households was about 3.89 acres with standard deviation of 3.63 compared 2.95 acres used by non-participants.

Livestock ownership

The main livestock kept by households were zebu short-horned cattle, sheep and goats. These were mainly kept as the main source of livelihood (for milk and blood as food). Further, households kept for prestige within the society and for marriage processes and other traditional rites of passage. On average, participating households in DEWS owned 6 cattle with standard deviation of 11.76 compared to 4 cattle with standard deviation of 6.86 owned by the control households (Table 3). The average earnings from cattle sales per year were higher for the DEWS participating households at UGX 249,502 (approx. USD 70) with standard deviation of 705,715 compared to UGX 117,803 (approx. 33USD) with standard deviation of 291,234 for non-participating households.

Crop production

The main crops grown were sorghum (58%), maize (26%) and groundnuts (10%) for the DEWS participants and non-participants. The average production levels for maize, millet and groundnuts were significantly higher ($p \leq 0.01$) for participating households in comparison to the non-participating households in Kotido District and significantly different for maize and millet at $p \leq 0.01$ and

Table 2 Land ownership and utilization in the Karamoja subregion

Item	Non-participating households			Participating households		
	Pooled (*N* = 132)	Kotido (*N* = 65)	Nakapiripirit (*N* = 67)	Pooled (*N* = 173)	Kotido (*N* = 86)	Nakapiripirit (*N* = 87)
Average total land owned	4.72 (4.82)	5.19 (6.12)	4.26 (3.09)	7.19 (12.09)	8.46 (15.83)	5.75 (5.16)
Average total land used	2.95 (2.14)	3.11 (2.08)	2.79 (2.20)	3.89 (3.63)	4.032 (3.86)	3.72 (3.38)

The figures in parentheses = SD

Table 3 Livestock ownership and sales among households in the Karamoja subregion

	Non-participating households			Participating households		
	Pooled (*N* = 132)	Kotido (*N* = 65)	Nakapiripirit (*N* = 67)	Pooled (*N* = 173)	Kotido (*N* = 86)	Nakapiripirit (*N* = 87)
Average number of cattle owned	3.55 (6.86)	4.32 (8.73)	2.81 (4.27)	5.77 (11.76)	4.93 (8.1)	6.72 (14.88)
Average earning from cattle sales per year (UGX)	117,803.03 (291,234)	148,769.23 (343,404.4)	87,7761.19 (228,332.7)	249.502.89 (705,715)	270,108.70 (582,343.7)	226,098.77 (827,029.19)

The figures in parentheses = SD

Table 4 Crop production level (kilograms/acre) of the households in Karamoja subregion

	Kotido (*N* = 151)			Nakapiripirit (*N* = 154)		
	Non-participating households	Participating households	*t* value	Non-participating households	Participating households	*t* value
Sorghum	363.86	247.64	0.612	143.19	207.25	0.111
Maize	40.00	103.47	0.001***	33.21	115.98	0.008***
Millet	6.67	43.15	0.043***	0	14.69	0.011**
Pearl millet	0	0.41	0.194	0	0.86	0.195
Sunflower	9.85	10.29	0.909	15.20	15.25	0.995
Groundnut	17.73	70.71	0.032**	11.83	35.04	0.107
Cassava	0	1.05	0.319	0	0	–

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

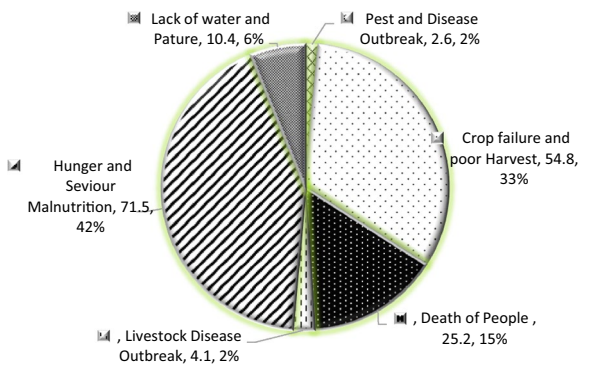

Fig. 2 Perceived effects of drought at household (*N* = 270) *Source*: Authors' Own Survey 2015

$p \leq 0.05$, respectively, for Nakapiripirit. There was no evidence that sorghum production was significantly different between the DEWS participating and non-participating households (Table 4). Results in Table 4 show that DEWS households adopted other crops such as maize, millet and groundnuts. Further results emerging from key information interviews indicated that the Karamojong perceive cassava as any shrub, which does not need to be grown thus their reference to cassava as "*eloma bon*" (translated as that which grows by itself).

Agro-pastoralists perception of food security

Several respondents (99%) indicated that they had experienced a drought in the last ten years. These droughts led to deleterious effects such as hunger and famine, death to some people and livestock disease outbreaks and deaths. The major effects reported by the respondents at household level were crop failure and poor harvest (33%) plus hunger and severe malnutrition (42%) (Fig. 2).

About 99% of the study respondents reported that they experienced severe food shortage as a result of drought. Perceived food scarcity was reported to be acute in the months of April, May and June. Drought was perceived by all respondents as the major cause of food insecurity. During one of the focus groups' discussions in Regen, Parish in Kotido District, one of the participants indicated that "*Since 2007, we have had consistent drought with crop failure that has led to households being continuously food insecure every year.*" Figure 2 shows that hunger and severe malnutrition were rated highest followed by crop failure. One would argue that crop failure leads to hunger and severe malnutrition. When the respondents were asked to mention the factors for recurrent drought in the area, they mentioned bush burning, overgrazing and conflict.

It was established that women were most affected during times of food scarcity as mentioned by 54% of the

study respondents. This was reinforced by findings from focus group discussions where one of the respondents noted that that "*children and women have to wait for residues or dregs from the local brew* ('ebutai'and 'Ajon') *made of sorghum and finger millet respectively to be eaten as food*." At times, the residue dregs are sun-dried and ground to make flour to provide local bread "ngatap" for the family (FGD Respondent Regen Parish). There was a difference between the DEWS and non-DEWS participants as regards the number of meals eaten in during times of food scarcity. More respondents from the participating category (42%) reported having one meal a day compared to 35% non-participating category who reported having one meal during times of scarcity. Furthermore, 27% of participating households compared to their non-participating counterparts noted that they had more than one meal a day during times of plenty. The major foods eaten by the households were cereals, milk, pulses, meat, vegetables and ghee. The foods eaten least by the households were root tubers fish and eggs.

About 48% provided casual labor in exchange for food, 41% sold firewood, grass and water to purchase food and only 8.5% planted vegetables as coping response to drought events. Marginally, there were respondents that indicated that they operated a small business enterprise and obtained food relief from NGOs and government as a coping mechanism to drought.

Effect of drought early warning systems on household food security using the household food insecurity access score (HFIAS) and household dietary diversity score (HDDS)

The results in Tables 5, 6, 7 demonstrate the effects of drought early warning systems on household food security in Karamoja subregion.

Results in Table 5 show a significantly higher average household dietary diversity score of 9.0 for DEWS intervention beneficiaries compared to 6.6 for the non-participating households. This means that DEWS households consume more dietary diverse food compared to the non-participating households. The results in Table 5 further revealed significantly higher household food insecurity (access score of 8.2) for the non-participating households of DEWS compared to 7 for their counterparts, the DEWS participating households.

Table 5 Comparison of food security between DEWS participating households and non-participating households using HFIAS and HDDS

Variable	Participating households	Non-participating households	*t* statistics	*p* value
HDDS	9.0	6.6	−6.2	0.000***
HFIAS	7	8.2	4.7	0.000***

Factors affecting household food security outcome

The household food insecurity access scale (HFIAS) was used as a measure of household food security. Results

Table 6 Factors affecting household food security outcome among respondents in the Karamoja subregion

Variable	Coefficient	SE	*p* value
Gender (1 = male, 0 = female)	0.037	0.2358	0.489
Participation in DEWS	−0.237	0.2289	0.000***
Age	−0.037	0.0094	0.518
Education	−0.078	0.048	0.150
Distance to water source	0.131	0.0972	0.014**
Number of acres owned	0.260	0.0166	0.001***
Number of acres used	−0.264	0.0586	0.002**
Household labor	−0.056	0.0441	0.432
Distance to local trading center	−0.191	0.03025	0.000***
Generalized linear models	No of obs = 305		
Optimization: ML	Residual *df* = 295		
Deviance = 1139.320	(Value/*df*) Deviance = 3.862		
Pearson = 305.000	(Value/*df*) Pearson = 3.862		
AIC = 1289.505			
BIC = 1330.428	Log likelihood = −633.752		

Dependent variable: proportion of HFIAS score of respondents

Table 7 Factors affecting household dietary diversity score among respondents

Variable	Coefficient	SE	*p* value
Gender (1 = male, 0 = female)	0.042	0.3752	0.442
Participation in DEWS	0.306	0.3644	0.000***
Age	−0.027	0.0149	0.635
Education	0.108	0.0535	0.048***
Distance to water source	0.086	0.1547	0.107
Number of acres owned	−0.074	0.0263	0.324
Number of acres used	0.138	0.0933	0.106
Household labor	−0.034	0.0701	0.631
Distance to local trading center	−0.136	0.0584	0.010***
Generalized linear models	No. of obs = 305		
Optimization: ML	Residual *df* = 295		
Deviance = 2885.922	(Value/*df*) Deviance = 9.783		
Pearson = 2885.922	(Value/*df*) Pearson = 9.783		
AIC = 1572.488			
BIC = 11624.899	Log likelihood = −775.488		

from the GLM model (Table 6) showed that the amount of land owned and distance to water source have a positive and significant influence on household food insecurity.

On the other hand, results in Table 6 show that participation in DEWS significantly ($p \leq 0.01$) reduced the threat of food insecurity by 23.7%. The study also revealed that a number of acres utilized by the households significantly ($p \leq 0.05$) reduce the threat to food insecurity. A unit increase in the number of acres used by the household reduces the threat to food insecurity by 26.4%. Results from the study further showed that a unit increase in the distance to the local trading centers reduced the threat to food insecurity by 19.1%, since the increase in the distance to trading centers reduced chances of selling of food at the trading center.

Results in Table 6 indicate that a unit increase in the total acreage of land owned by a household significantly ($p \leq 0.05$) increases the threat of food insecurity by 26%. This is because the total land reportedly owned by the respondents is actually communal land which is used for grazing cattle, limiting crop production, yet cattle is not sold for buying food item. This increases food insecurity since the land is used for cattle keeping instead of food production. A unit increase in the distance to water source significantly ($p \leq 0.05$) increases the threat of food insecurity by 13.1%.

Factors affecting household nutrition outcome

Results in Table 7 indicate the major factors influencing the nutrition outcome of households in Karamoja subregion.

Participation in DEWS, education level and distance to the trading center significantly influenced the household dietary diversity consumption. Participation in DEWS resulted to an increase of HDDS by 30% for the DEWS households, and this could be due the Project intervention activities and access and utilization of information. In addition, those who were education had a 10% increase in HDDS. The results further showed that a unit increase in the distance to the trading center results into a 14% increase in HDDS.

Discussions

Household's perceptions and experiences of food security

This study has shown that drought is a major cause of food insecurity at household level in Karamoja subregion. This is exacerbated by the poor household socioeconomic conditions. These patterns could be attributed to the fact that most households in the subregion are impoverished and with low education levels [18, 22]. This makes them unable to purchase food, a situation closely associated with poverty [6] in several agriculture-based rural areas. Although Karamoja subregion has faced food insecurity since 1964, and depended on relief food, [7], one would have expected a considerable change as of today following several interventions in the region aimed at security food security. However, this study has shown that several of these interventions have not led to food security in the region as most of the households continue to whirl in food deficits. Previous studies in the region and elsewhere in the semiarid areas have linked food insecurity in these areas to drought Vlassenroot et al. [34] and Turyahabwe et al. [35] events.

This study has showed that the sociocultural practices by the agro-pastoralists have placed women as more vulnerable to food insecurity. This is more evident with an average household size of 10 members, higher than the national average size currently at 6 members [22]. During times of scarcity, it is the women and children who are more affected by food insecurity. This is because culturally in Karamoja subregion, it is the role of women to fend for their families that is to bring food to the table. The role of the man is basically to look after livestock and provide security to the family. It is the sole role of women in Karamoja to carry out land tillage or crop production. However, currently the livestock has reduced due to the conflicts/raiding situation has caused this men to wake up in the morning and lie idle under trees the whole day while the women are struggling with household chores including "manyatta" or hut construction.

Ownership of more land by participating households is accounted for by the initial criteria for selection of the participating households. NGOs generally tend to select those who can be able to implement their project activities. That means working with people with access to land. However, the more land tilled by the participating households' mean they developed more interest in crop production due to training and exposure outside Karamoja. The situation in Karamoja is that most of the households predominantly have pastoral livelihoods. Crop production is still something that they are just adjusting to do.

As coping strategies for food insecurity, the households tend to use dregs from local beer as food, collect wild fruits and vegetables, and use money from sale of firewood, water, grass to purchase food. From the coping strategies, one may argue that they mainly depend on natural resources as coping strategies. The main source of livelihood for pastoralists is livestock that has been affected by the current practice of protected kraals by Uganda Peoples Defense Forces that involves keeping all the animals in one big kraal against the cattle rustlers. This view was alluded to by the study on pastoralists in the same region [16]. All this limits access of the livestock resource by the other household members at home. During times of plenty, which is usually after a good year of

harvest, households tend to carry out most of the postponed rituals of feasting: naming of new born, initiation into adult hood for the boys, marriage ceremonies and appeasing of the small gods. These kinds of ceremonies tend to exhaust most of the food harvested, and within a few months, the communities are food insecure again. With such practices, one would argue that their cultural practices in addition to drought make them more prone to food insecurity.

Ownership of more land by participating households is based on the initial criteria for selection of the participating households. It is a practice by NGOs to select those who can be able to implement their project activities the "resource-poor." However, the more land tilled by the participating households' would mean they developed more interest in crop production due to training and exposure outside Karamoja through tours for example to Teso subregion. The situation in Karamoja is that most of the households are still stuck to their traditional livelihood of pastoralism where livestock is the main resource. Crop production is still something that they are just adjusting to do.

Effect of DEWS on household food security and household dietary diversity

DEWS participating households have a significantly different HDDS of 9.0 compared to 6.6 for non-participating households and a significantly higher household food insecurity access score of 8.2 for the non-participants of DEWS intervention compared to 7 for their counterpart who were DEWS participating beneficiaries. This means that DEWS participating households are better off than the non-participating households as far as food access, availability and utilization are concerned.

To enhance the ability of the drought early warning system calls for further trainings on drought management, information from the early warning system and support with improved seed [16, 18], watering cans for mini-irrigation and exposure through participations in workshops within and outside Karamoja enabled them to get insight of what others do to enhance food production.

The trainings and information they receive from DEWS enabled them to diversify production. Similar findings on farm diversification can positively improve household food security and nutrition outcomes by increasing household's access to diversified diets and to nutrient-rich foods [36] from own production. This includes growing drought-tolerant varieties that guarantees harvest hence food security. Although diversification per se is not sufficient in ensuring household food security and nutrition as Kikafunda et al. [37] noted, there are areas where total amount of food seemed to be sufficient, but with households not achieving a diversified diet.

Others factors that significantly increased the HFIAS were distance to water source and number of acres owned. This is due to the time spent on looking for water instead of doing food generating activities since water is used for both domestic and mini-irrigations of vegetable gardens.

The scenario that an increase in number of acres owned by households increases the food insecurity situation for that household could be as a result of most households with big numbers of acres of land use it for grazing livestock in a communal way. Also in such an environment, crop production turns out to be very expensive, and households involved in crop production have to fence off their crops with reeds and thorns to prevent destruction by animals. Although a study by Faridi and Wadood [38] found total land owned by a household a significant positive impact on food security status, the finding of this study might be unique to the context of Karamoja subregion where cultural practices do not add to food access, since cattle is mainly kept for prestige and very few can afford to sell livestock to buy food as indicated in Table 3.

On the other hand, findings show that a unit increase in the number of acres put to use within the household for crop production reduces HFIAS by 24% and the distance to the trading center reduces HFIAS by 19%; one study [39] also reported that increasing the land area allocated to crops can improve the food security of rural farm families. Similarly, as the distance to the trading center increases, households become more food secure; the explanation for this is that the further the trading center, the better, as this means that the households do not spend a lot of their time in the trading centers drinking, but remain home tilling land and less food can be sold during the times of plenty.

Participation in DEWS, education level, distance to the trading center all positively significantly affected the HDDS of the households (Table 7). In Ethiopia, Gebre [40] found a positive relationship between education level of household head, asset possession and access to employment, credit services and household food security. In general, this study implies that DEWS project increase both dietary diversity and anxiety of food insecurity. This is due to more food crops of the improved varieties being grown by the DEWS households as compared to the participating household who majorly are involved in growing mainly traditional food crop of sorghum. This can be attributed to the fact that the DEWS households have more information on droughts that push them to store more food for any eventuality compared to the non-participating households who lack information on droughts. Basing on the Karamoja subregion context, the issue of diet is not very key, what is very important is being able to secure a meal. Although most of the households could

have access to milk and blood from those who own Livestock, the practice of moving far with livestock in search of pastures and water keeps the households far from the resources.

Conclusions and recommendations

This study has confirmed that drought is a major cause of food insecurity at household level in Karamoja subregion. The effect of drought is exacerbated by the poor household socioeconomic conditions. The study further shows that sociocultural practices in the study area have made women more vulnerable to food security. As ways of coping with food security challenges, the households in the subregion have devised strategies such as using dregs from local beer as food, collecting wild fruits and selling firewood, and water and grass to buy food. The study also indicates that the DEWS program significantly contributes to food security and increases in dietary diversity. It also reduces the anxiety of being food insecure among the local people in Karamoja subregion. Consequently, given the high prevalence of droughts and its associated effects on food security in the region, drought early warning systems need to be scaled out to other areas facing food insecurity and drought in semi-arid areas. There is also need for practitioners of DEWS to integrate pasture conservation, and use of drought-tolerant seeds as a way of building the capacity of communities in coping with the challenges of prolonged drought.

Abbreviations

ATAAS: Agricultural Technology and Agribusiness Advisory Services Project; CC: contingency coefficients; DEWS: drought early warning system; GLM: generalized linear model; HDDS: household dietary diversity score; HFIAS: household food insecurity access score; NARO: National Agricultural Research Organization; NGOs: non-governmental organizations; SSA: sub-Saharan Africa; UGX: Uganda shillings; VIF: variance inflation factor.

Authors' contributions

DA designed the study, collected data, analyzed the data and drafted the initial manuscript. BBO initiated the statistical technique used in the analysis, reviewed methods and tables and advised on some of the material cited. NT reviewed the entire manuscript and recommended the journal for publishing as well as making changes to the analysis, results and discussion sections of the report. AE & YB as members of the Doctoral Committee reviewed the manuscripts and advised on analysis and presentation of results. All authors read and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests.

Availability of supporting data

Data sets used for analysis of findings in the study are available from the corresponding author on reasonable request.

Ethical approval and consent to participate

All respondents were informed about the purpose of the study. They were assured that the data collected from them were purely for academic purposes. In addition, their consent to participate in the study was sought before commencement of data collection.

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