Growing Hope in Dry Lands: A Look at How Tanzania's Smallholder Farmers Thrive Despite Drought

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Abstract

The occurrence and spread of droughts in recent years have limited productivity and resulted in food insecurity for most smallholder farmers. Though there are options for adopting drought-resistant crops, the rates and level of adoption are questionable as many smallholder farmers still engage in their traditional ways of crop production. Therefore, this study examined determinants of smallholder farmers' adoption of drought-resistant crops and the choice of adaptation strategies to drought in the Kishapu District. Using cross-sectional data obtained from 242 households. A probit model was used to examine the factors determining the adoption of drought-resistant crops while a multinomial logit model was used to examine the factors influencing the choices of drought adaptation strategies. Results show that household head age, distance from farm input markets, participation in village meetings, access to extension services, access to information, and access to credits are the influencing factors for drought-resistant crop adoption. On the other hand, household income, experience, distance from farm inputs, access to weather information, access to extension services, and gender were found to be significant factors influencing choices of adaptation strategies to drought and climate change in the study area. Therefore, proper and extensive farming extension services covering all age groups and relevant farming knowledge should be compulsory to increase smallholder farmers' adoption of drought-resistant crops. Also, establishing proper market channels is crucial for the input market, enabling communities to access inputs at the right time and at an affordable price.

Keywords: Adoption, drought-resistant crops, adaptation strategies, Tanzania

Introduction

Agriculture is the key sector fostering economic growth and development in most developing countries. Tanzania is one of developing countries where agriculture is the main source of income for its citizens, who depend mostly on farming activities. Generally, agriculture contributed 29% to the Gross Domestic Product (GDP) and employed about 65.5% of Tanzanians and in favourable seasons covers more than 100% of the domestic food needs (URT, 2021; Msengi and Akyoo, 2023; Kitole *et al.,* 2024). Hence, the sector plays a big role in the reduction of poverty if it is well managed (Herrmann, 2017). The issue of agricultural drought limits contribution of the sector to the economy. Currently, drought has been reported as one of the biggest global problems, but its associated impacts and vulnerability vary across the globe and regions (Fisher *et al.,* 2015; Nathanel *et al.,* 2015; Msongaleli *et al.*, 2015; Liu *et al.*, 2019; Dai *et al.*, 2020; Atube *et al.*, 2021).

Despite the efforts made to reduce the impacts of drought in the world, like the introduction of climate adaptation programmes, soil conservation, and introduction of drought-resistant crop varieties, there are still significant effects of drought (Haile *et al.,* 2019; Ray *et al.,* 2020). It is approximated that nearly 30 per cent of the world's population lives in drylands and agricultural drought-prone areas, which cover more than 40 per cent of the world's land surface (Gaur and Squires, 2018; Warbuton, 2020; Wens *et al.,* 2021; Tanti *et al.*, 2022). Nearly 1/3 of the world population living in drylands and drought areas depend on agriculture for their food security and livelihoods, often as their only source of income (Bhattacharyya *et al.,* 2023). Increasing drought, therefore, affects all aspects of economic growth, especially in the least developed countries where the drought has direct adverse impacts on agricultural crop production, as it is in Tanzania where 75%-80% of Tanzanians earn their livelihood through smallholder agriculture and where more than 80% of crop production depends on rainfall (Gwambene *et al.,* 2023). The drought condition endangers the smallholders' income status and food security through the distortion of socio-economic bases, hence accelerating poverty among smallholder farmers' households (Kabote *et al.*, 2024). This implies that reduction in agricultural productivity for smallholder farmers would negatively affect food security and income status. This situation has led the country experiencing food shortages, especially in drought-prone areas as a result of crop failure due to increased drought (Maliki *et al.*, 2023).

Focusing on Tanzania, the country has observed a high increase in drought events in recent years, which threatens food security and livelihoods of most smallholder farmers (Gwambene *et al.*, 2023). The drought impacted about a million people in the northern portion of Tanzania, which left the country with a serious shortage of food and water. Increased droughts and climate variability have direct impacts on crop production in Tanzania because nearly 80% of agricultural production depends on rainfall (Mugabe *et al.*, 2024).

To reduce the impact of drought and enable smallholder farmers to have improved crop productivity and income, adaptation to drought-resistant crop production in developing countries, including Tanzania, is imperative now more than ever before due to the low productivity of traditional crop varieties. People engaging in smallholder farming practices are very much affected by the impacts of droughts (Mbilinyi *et al.*, 2013; Uddin *et al.*, 2014; Belay *et al.*, 2017; Nabara *et al.*, 2020; Drugova *et al.*, 2022). These studies further revealed that increasing drought and climate change are likely to cause more harm to smallholder farmers as they reduce and limit farm products. Smallholder farmers who have perceived the increase in drought and have better knowledge and information on drought are better placed since they are able to link drought conditions with changes in crop types and cropping patterns and thus cope with the situation. A better understanding of smallholder farmers' adaptation to drought-resistant crops is important to develop appropriate measures that can be helpful in mitigating the adverse impact of droughts in developing countries, Tanzania in particular (Uddin *et al.*, 2014; Msongaleli *et al.*, 2015; Tofu and Wolka, 2023).

Smallholder farmers in Kishapu District could have enough yields to ensure food security and sustained income if they could accept and produce drought-resistant crops, but since they are not, they are regularly faced with food shortages and low income (Matata, 2019). Provision of food hand outs by the government is now a common tendency in Kishapu District which provides evidence that drought has affected smallholder farmers' productivity hence leading to high food insecurity and income poverty (Matata, 2019). The smallholder farmers who were not engaged in drought-resistant crop production like millet, sorghum, and sweet potatoes reported being more food insecurity than those who were.

Despite the presence of options for smallholder farmers to reduce the impacts of drought through adopting drought-tolerant crops instead of their traditional varieties and non-drought-tolerant crops, the number of smallholder farmers engaging in the production of drought-resistant crops is very limited. To date, there is unclear information on factors that influence smallholders' decisions on whether to adopt or not adopt drought-resistant crops in the study area and what influences their choices of drought adaptation strategies (Zobeid *et al.*, 2021). Hence, considering the knowledge gap, the study on which this paper is based intended to bridge the gap by analysing the factors influencing smallholder farmers' adoption of drought-resistant crops and the choice of drought adaptation strategies in the Kishapu District. The study's distinctiveness comes in the analytical method, which is divided into two stages: first, identifying the factors that influence drought-resistant crop adoption, and second, determinants of diverse adaption strategies after drought-resistant crop adoption. Most of the previous studies focused on the general adaptation to climate change strategies and farmers' perceptions and not specifically on drought as a component of climate change

(Asrat and Simane, 2018; Makuvaro *et al.*, 2018; Bedeke *et al.*, 2019: Ojo *et al.*, 2020; Adeagbo *et al.*, 2021; Wale *et al.*, 2022; Tofu and Wola; 2023). Also, the types of combined drought-resistant crops used in this study as an independent variable is a unique variable that has not been included in previous studies of drought-resistant crops (Makate *et al.*, 2017; Lunduka *et al.*, 2019; Martey *et al.*, 2020). Hence, the results of this study would enrich our understanding of the smallholder farmers' adaptation strategies, factors influencing adaptation to drought, and factors influencing the choice of adaptation strategies in drought areas in developing countries and would be a guide to policymakers.

Theoretical Framework

The study was centered on the utility maximization theory in neoclassical economics. The theory explains that when an individual is to make a choice among given alternatives, for instance to adapt or not to adapt, the individual has a choice preference that aims at maximizing utilities by increasing levels of satisfaction. The neoclassical economic theory gives the necessary probability models to examine the factors influencing farmers' adoption of drought-resistant crops. A model for utility preference determines the decisions of people regarding choices of available alternatives of drought-resistant crop adaptation in order to maximize their utility. In this case, farmers' utility is observed through the action of the farmer in choosing adaptation strategies. Utility maximization is controlled by assumptions that people have rational preferences among the two outcomes or a variety of choices; individual action seeks to maximize utility and people act independently (Weintraub, 2002). Such utility is subject to the farmer's maximization of productivity and minimization of farm activity cost of production.

The assumption here is that farmers adopt drought-resistant crops only when the perceived utility or profit from producing the new crops is significantly greater than the traditional or unimproved varieties. Even though the utility is not observed, the actions of economic agents are observed through the choices they make (Deressa *et al.*, 2009). The utility maximization function is thus given as;

$$Uij = \beta jxi + \varepsilon j \text{ and } Uik = \beta\text{^'} kxi + \varepsilon k \quad (1)$$

where:

Uij and Uik are the perceived utilities by smallholder farmer i of adopting drought-resistant crops j and k respectively; xi is the vector of explanatory variables that influence the perceived desirability of crop variety; βj and β^' kβ^' k are the parameters to be estimated; while εj and εk are the error terms and are assumed to be identically and independently distributed.

If farmer i chooses crop j instead of k then it means that the perceived utility derived from this crop is greater than that for the latter. This can be expressed as:

$$Uij > Uik,\ k \neq j \quad (2)$$

Utility derived from an adoption strategy cannot be observed. However, what is observed is the discrete choice of the adoption strategy, which can then be related to this unobservable (latent) and continuous variable.

$$Yi=1 \text{ if } Uij>Uik \quad (3)$$

$$Uij-Uik> 0$$

$$(\beta jxi+ \mathcal{E}j)-(\beta' kxi+\mathcal{E}k)> 0$$

$$Yi=1 \text{ if} (\beta' i-\beta' k)Xi+(\mathcal{E}j-\mathcal{E}k)> 0 \text{ and}$$

$$Yi=0 \text{ if } ((\beta' j-\beta' k)Xi+(\mathcal{E}j-\mathcal{E}k)\leq 0$$

Based on the utility function provided, the common methods used for the analysis of the choice options of a farmer on adoption include probit and multinomial logit models. While the binary choice models are used when there are two options for a farmer to either adopt or not (Nathanel *et al.,* 2015), in the case of categorical choices, the multinomial logit model will be used to identify the socio-economic factors influencing the farmers' choice of adoption strategies of drought.

Conceptual Framework

This study investigates smallholder farmers' adoption of drought-resistant crops and their choice of adaptation strategies, focusing on various influencing factors. Two dependent variables are analyzed: the adoption of drought-resistant crops and the selection of adaptation strategies. The adoption of drought-resistant crops is assessed by asking households if they have adopted such crops, with responses being "yes" or "no." The choice of adaptation strategies is measured by inquiring about the types of strategies employed by households to cope with drought and climate change. The independent variables encompass a range of household characteristics, physical capital, financial capital, social capital, human capital, and other influencing factors. Household characteristics include the age of the household head, education level, household size, marital status, gender, and household income. Physical capital involves the location and size of the farm, while financial capital includes access to credits and household income sources. Social capital covers household social networks, group membership, and participation in meetings. Human capital pertains to access to extension services and household experience in environmental management. Other factors include the distance from farm input markets, drought observation incidence, presence of laws and regulations, and access to weather and climate information.

These variables were selected based on their mixed results in existing literature regarding their influence on smallholder farmers' adoption and adaptation choices. The study's hypotheses are derived from a review of literature on drought and climate change adaptation, including works by Deressa *et al.* (2009), Msongaleli *et al.* (2015), Uddin *et al.* (2014), Komba and Muchapondwa (2015), Sanga *et al.* (2013), and Nathaniel *et al.* (2015). The study's conceptual framework, illustrated in Figure 1, depicts how these factors influence smallholder farmers' decisions and contribute to adopting drought-resistant strategies. The independent variables are posited to have a directional influence on the dependent variables, indicating cause-effect relationships. This framework aims to understand better the dynamics behind smallholder farmers' adaptation to drought and climate change.

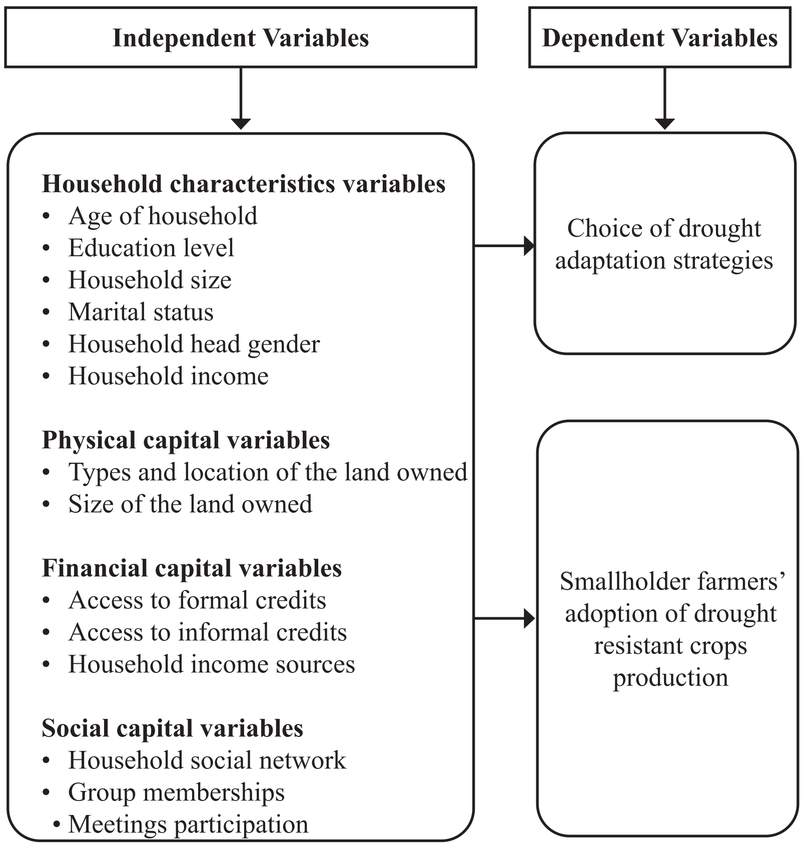

Figure 1: Conceptual framework

Source: Researcher's own construct

Methodology

Study Area

The research was conducted in Kishapu District Council. Kishapu District is one of the three districts forming Shinyanga Region; the other two are Kahama and Shinyanga. The main economic activities carried out in the district are agriculture, livestock keeping, small-scale mining, and trade (URT, 2017). A map showing the study area is attached. Kishapu District Council was chosen as a study area for this research since it is among the districts where drought has affected crop production because of a failure to adopt drought-resistant crops. The district has been experiencing a shortage of food and a decreasing yield from both food crops and cash crops as farmers continue producing unimproved varieties of seeds and crops which are not resistant drought and other climatic shocks.

The study was specifically conducted in Bunambiyu, Kishapu, Uchunga, Mwadui Lohumbo, and Ndoleleji wards in representative villages. Selection for these wards was randomly done to represent other wards of the district. Thus, this study on determinants of smallholder farmers' adoption of drought-resistant crops and choice of drought resistance strategies in the district could serve as a driver for improving the adoption of drought-resistant crops and choice of better drought adaptation strategies in the study area and the country at large.

Sampling procedures

Kishapu District has approximately 50,553 households found in three divisions and 25 wards with some common geographical characteristics. In this study, a sample of 255 households was taken from five wards and five different villages to represent the other wards in the district. To select these respondents, a two-stage sampling approach was employed. First, five wards out of 25 wards in the Kishapu District were randomly selected. Second, using a systematic sampling method, equal numbers of households were selected in each ward from five villages. In this case, lists of households were first obtained from the Village Executive Officers (VEOs). A simple random sampling technique was used to obtain a representative sample from each village. Since the study population was 5,900 households possessing homogeneous characteristics and considering that 70% of the households were involved in agricultural activities, the sample was calculated from this 70%, which was 4130 households. This sampling procedure was very useful since the sampling frame was available in the form of lists that were available at the village and ward offices.

Sample Size

In this study, the formula by Yamane (1967), cited in Polonia (2013), was used in calculating the suitable research sample size. The sample size of the study was 255 respondents (51 households from each village of the five wards). However, during the fieldwork, only 242 respondents were contacted and interviewed using a structured questionnaire and gave their responses (Table 1).

Analytical framework

For the purpose of analysing the relationship between the selected socio-economic factors in determining the smallholder farmers' adoption of drought-resistant crops in Kishapu District, a model of choice was used. Many of the studies

Table 1: Respondents by Location

S/n	Ward	Villages	Community members	Total
			Household members	
1	Ndoleleji	Ndoleleji	48	48
2	Uchunga	Uchunga	50	50
3	Kishapu	Mhunze	48	48
4	Mwadui Lohumbo	Mwadui Lohumbo	49	49
5	Bunambiyu	Bunambiyu	47	47
Total number of respondents			242	242

cited in this study used either a probit model (Sanga *et al.,* 2013; Uddin *et al.,* 2014; Nathanel *et al.,* 2015; Komba and Muchapondwa, 2015; Bahinipati and Venkatachalam, 2015) or a multinomial logit model (MNL) as in (Deressa *et al.*, 2009; Fisher *et al.*, 2015; Msongaleli *et al.*, 2015) in estimating the factors influencing adaptation to climate change and drought conditions by small-scale farmers. The selection of MNL was due to its simplicity in its computational simplicity over the Multinomial Probit model, though both can give similar findings.

The Probit Model

To determine factors influencing smallholder farmers' adoption of drought-resistant crops in the study area, the conventional practice of using a discrete and limited dependent variable model was preferred. Since the random preferences were not known and could only be predicted through the probability statements about the binary responses of either 'yes' or 'no', a Probit model was used to estimate the probability of adaptation to drought resistant crops production. The probit model was preferred for this study since it gives a statistical fit to data that is equal to or superior to other models.

The error term was symmetrically distributed around zero. However, the drawback of the probit model was that the response probability did not have the probit form; this is the case when the error term does not have a standard normal distribution. The model also lacks flexibility as it does not easily incorporate more than one prediction variable. Regardless of its shortfalls, the probit model was useful in this study as it was used to draw a conclusion for policymakers on possible interventions that needed to be undertaken following the expected findings.

The probit model is therefore based on the utility maximization function as presented in equation (1) in section 2.2. It is assumed, therefore, that an individual smallholder i has a determinants choice represented by:

$vij=\beta jxi+\mathcal{E}i$ ....(6)

Where Uija smallholder adaptation utility xi represents the vector of explanatory factors and signifies the systematic random error with a zero mean and a unit variance that arises from the unobserved factors about i's adaptation.

Smallholder farmers may or may not be willing to adapt to drought-resistant crops. In that situation, the dependent variable assumes a latent (unobserved) status as represented by the following equation:

$yi= Xi\beta+\mathcal{E}i$ ....(7),

where yi is the unobserved dependent variable

β is a parameter of the model (intercept and confident)

Xi is exogenous (independent) explanatory variable and,

$\mathcal{E}i$ is the error term

If an individual smallholder farmer i has adapted to drought-resistant crops, yi = 1 and otherwise yi= 0 (zero)

Mathematically, this is given by:

$yi.$ = {1 if yi = 1; (smallholder farmer adopted of drought resistant crops); 0 otherwise}

When yi^* = 1, then yi = 1 implying the specific smallholder has adopted of drought-resistant crops. The probability that a household would be willing to adopt can be estimated by the probit model below:.

$$Prob\ (x) = 2\pi - \frac{1}{2} exp\ exp\ \left(-(\beta xi)2/2\right) .....(8)$$

where:

yi= is the dependent variable (willing to adapt) taking a value of 0 or 1

Xi is the vector of explanatory variables of the age of respondents, level of education, household size, farming experience, household main occupation, location of the farm, size of the land owned, access to formal credits, access to informal credits, household income source, network, group memberships, meetings participation, access to extension services, experience in environmental management, distance from farm inputs and outputs, access to weather and climate information, the incidence of droughts observation and presence of laws and by-laws. β is the coefficient vector.

Therefore, the regression equation will be:

$$\gamma i = \alpha + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4 + \beta 5X5 + \beta 6X6 + \beta 7X7 + \beta 8X8 + \beta 9X9 + \beta 10X10 + \beta 11X11 + \beta 12X12 + \beta 13X13 + \beta 14X14 + \beta 15X15 + \beta 16X16 + \beta 17X17 + \beta 18X18 + \beta 19X19 + \mu$$

where:

$$\frac{\delta Pi}{\delta xi} = \left[\frac{e\beta' xi}{1+e\beta ixi}\right] = \beta i \quad ....(9)$$

$$F(\beta' X)[(\beta' X)]\beta i \quad ....(10)$$

The Multinomial Logit (MNL) model

The multinomial logit (MNL) model was used to identify the influencing factors for smallholder farmers' choice of adaptation strategies in Kishapu District Council. The MNL parameter estimates were obtained using the maximum likelihood estimation method given in the MLOGIT command for STATA version 11. The explanatory variables used to describe the choice of crops and crop varieties are shown in Table 2. The underlying assumptions of this model are that the dependent variable is the log of the odds ratio which is a linear function of the repressors. The probability function that underlies the logit model is the logistic distribution (Gujarat, 2004).

The advantage of using this model is that it permits the analysis of decisions across more than two categories, allowing the determination of choice probabilities for different categories (Deressa *et al.,* 2009). Given that information, the multinomial logit model will be used to identify the socio-economic factors affecting smallholders' farmer adaptation to drought-resistant crops, using the functional form of the model. Let A, be a random variable representing the adaptation measures chosen by any smallholder farmer. We assume that each smallholder farmer faces a set of discrete, mutually exclusive choices of adaptation measures. These measures are assumed to depend on a number of drought attributes, socioeconomic characteristics, and other factors X. The MNL model for adaptation choice specifies the following relationship between the probability of choosing option A and the set of explanatory variables X (Green, 2003).

$$Prob\ (Ai = J|Xi) = e\beta' j\beta i, 1 \quad ....(11)$$

$$\sum_{k=0}^{j} e^{\beta} k^{x}\ i \quad ....(12)$$

where βj is a vector of coefficients on each of the independent variable X. Equation (11) can be normalized to remove indeterminacy in the model by assuming that $\beta 0 = 0$ and probabilities can be estimated as:

$$Prob\ (Xi) = e^{\beta}\ j^{x}\ i$$

$$1+\sum_{k=1}^{j} = e_k^{\beta} xi, j = 0,2 \cdots j, \beta o = 0$$

$$1+\sum_{k=1}^{j} = e_k^{\beta} xi, j = 0,2 \cdots j, \beta o = 0. \quad ....(13)$$

Maximum likelihood estimating equation (2) yields the J log –odds ratios

$$In\left[\frac{pij}{pik}\right] = xi(\beta j - \beta k) = xi\beta j, if\ k = 0$$

$$In\left[\frac{pij}{pik}\right] = xi(\beta j - \beta k) = xi\beta j, if\ k = 0 \quad ....(14)$$

The dependent variable is, therefore, the log of one alternative relative to the base alternative. The MNL coefficients are difficult to interpret, and to associating the with the th outcome is tempting and misleading. To interpret the effects of the explanatory variables on the probabilities, marginal effects are usually derived as Greene (2003) did.

Therefore, the full model is specified as follows:

$$y = \beta iXi + \mathcal{E}iJ \quad (15)$$

where: βi's are parameters to be estimated, y are adaptation options (or alternatives); Xi is a set of independent variables; and are the error terms.

Results and Discussion

Household characteristics of participants

Table 3 provides a summary of the household characteristics of participants in the study area. The basic information of households from the study area (socio-economic characteristics) is shown in Table 3. This comprises the age, gender, marital status, level of education, size of the household, occupation of the household head, and annual income. The results showed that the minimum and maximum age of the respondents was 18 and 89 years respectively averaged at the mean of 43 years. Of the respondents, 78% were male and 22% were female. Concerning marital status, 79% of the respondents were married, 18.60% were widows or widowers, and 4.13% reported that they were divorced while 2.48% of respondents were single. In terms of educational level, only 25% of respondents reported not to have been to school or ended standard four and below while 75% completed primary education and or

Table 2: Description of the variables, its measurement, and a priori expectation

Household characteristics variables			
Variables	**Description**	**Measurement**	**Expected sign**
Age of household head	The actual number of years of respondent's age	Years	+
The education level of household head	Number of years the respondent spent in the formal education	Years	+
Household size	Dependent Vs workers household members	Number	+/-
Farming experience	Number of years which the respondent had spent in agriculture activities	years	+
Household main occupation	Types of activity that household is involved with and return received	Tshs	+/-
Physical capital variables			
Size of the land owned	Total size land owned by the household	Number of acres	+/-
Location of the farm	A dummy that tells whether the respondent is located nearby farm source of water	Dummy: 1 if respondent is located near the source of water; 0 if otherwise	+/-
Financial Capital Variables			
Accessibility to formal credit	Amount of credits from formal financial sources	Tshs	+
Accessibility to informal credit	Amount of credits from informal sources	Tshs	+
Household income	The average monthly income earned by the household head	Tshs	+
Social Capital Variables			
Household network	A dummy variable that tells whether the respondent has social network	Dummy: 1 if respondent has accesses to the social network; 0 if otherwise	+
Household group memberships	A dummy variable that tells whether the respondent have memberships in social groups	Dummy: 1 if the respondent has memberships in social groups; 0 if otherwise	+/-
Social meetings participation	A dummy variable that tells whether the respondent is participating in social meetings	Dummy: 1 if the respondent is participating in social meetings; 0 if otherwise	+/-

Table 2: Description of the variables, its measurement, and a priori expectation

Variables	Description	Measurement	Expected sign
Household characteristics variables			
Human Capital Variables			
Availability of farming extension services	Number of times received the extension services per season	Number	+
Household Experience in environmental management	A number of years household has participated in environmental management activities.	Years	+/-
Other Variables			
Distance from farm inputs markets	Number of Kilometers' distance from the farm inputs markets	Kilometers	+/-
Access to output market	A dummy variable that tells whether the respondent had accessed the output markets	Dummy: 1 if respondent accessed output market during last harvest; 0 if otherwise	+/-
Presence of laws and regulations	A dummy variable that tells whether the existing laws and regulations guiding adaptation to drought-resistant crops are applicable.	Dummy: 1 if there are laws and regulations are applicable; 0 if otherwise	+/-
Incidence of drought observation	A dummy that tells whether respondents have observed the incidence of drought during the last 3 years in the study area	Dummy: 1 if respondent has observed incidence of drought; 0 if otherwise	+
Access to climate information	A dummy that tells whether the respondent access climate information	Dummy: 1 if respondent access; 0 if otherwise	+

college/university levels respectively whereby the average education years was 7 years and the maximum and minimum education years was 16 and 0 years respectively. Also, the results indicated that the average number of members of the household was 6, whereas families with a household of 4-6 members were 39%, 7-8 members were 31%, 1-3 members were 16% whereas a household with 9 members and above was 13%. From the field, it was It was observed that 53% of all household members were actively working while 47% were dependents. On top of that 52% of the dependents were females, whereas 48% were males.

With regard to the occupation of respondents, the findings showed that 54% were self-employed in agriculture, 11% were self-employed as traders, and 3% of respondents were government employees or other formal institutions, while the rest (33%) were occupied in the other activities mentioned. On the other hand, the average annual household income revealed that 40% received between 0.5-1Million, 24%, 17%, 9%, and 9% received between 1-2 Million, <0.5Million, 2-3Million, and >3Million respectively. The study findings further revealed that the main source of income was farming activities with 84%, business

Table 3: Descriptive statistics of households' socio-economic characteristics

Socio-economic characteristics		Number of Respondent / Findings	Percentage (%)
Variables	**Variables description and measurements**		
Average age	Average household head years	43	
Gender	Male	188	77.7
	Female	54	22.3
Marital status	Single	6	2.48
	Married	181	74.79
	Widow	45	18.60
	Divorced	10	4.13
Number of years in formal education	Average education years	7	
	0 years	13	5
	1-7 years	179	74
	8-12 years	43	18
	12+ years	7	3
Household Size	1-3 members	39	16
	4-6 members	95	40
	7-8 members	76	31
	9> members	32	13
	Average household size number	6	
Household members working ration	Active members	764	53
	Dependent members	680	47
	Male dependent	298	44
	Female dependent	382	56
Occupation of the respondents	Other employed male	243	17
	Other employed female	223	16
	Male employed in agriculture	401	29
	Female employed in agriculture	354	25
	Male trader	92	7
	Female trader	49	4
	Male government and formal institution employed	21	2
	Female government and formal institution employed	9	1

Table 3: Descriptive statistics of households' socio-economic characteristics

Socio-economic characteristics		Number of Respondent / Findings	Percentage (%)
Variables	Variables description and measurements		
Average household annual income	<0.5MnTshs	42	17
	0.5-1MnTshs	98	40.5
	1-2MnTshs	58	24
	2-3MnTshs	22	9
	>3MnTshs	22	9
	Average annual household income	1,514,140	
Source of income	Income from other activities	466	33
	Income from agriculture	755	54
	Income from trade activities	141	11
	Income from government	30	3

Source: Field Survey (2018)

profits 7%, wages 2%, relatives and friends 2% and other sources were 5%.

Drought Adaptation in the Study Area

Table 4 presents the variables used to determine the level of adaptation and strategies used to adapt to the drought conditions and climate change in the Kishapu District Council. The results show that 84% of all respondents from the study area have already adapted to drought conditions and general climate change in Kishapu District Council, whereas only 16% have not yet adapted to the drought and climate change in the study area. However, the results revealed that 98% of the respondents were aware of the drought conditions and climate change, whereas only 2% were not aware of the situation.

In regard to the adoption strategies employed by smallholder farmers in the study area to adapt to drought conditions, the respondents interviewed mentioned the variety of crops like planting drought-resistant crops as their main strategy by 42%. The results further mentioned the changing planting dates at 24%, moving to nonfarm activity at 15%, irrigation of the crops at 14%, and soil conservation at 5% as their respective adaptation strategies. The findings further showed that 27% of the interviewed respondents were producing sorghum, 21% adapted to bush millet as a drought-resistant crop, 14% adapted to sweet potatoes, 10% adapted to chickpeas as a drought-resistant crop, and 7% of the respondents adapted to sunflower as their main drought-resistant crop in the study area, while 22% took other measures for adaptation.

In examining the reasons for drought resistance and climate change adaptation in Kishapu District, it was found that 58.02% of the respondents adapted because of the prolonged shortage of rainfall, while 22.63%, 9.88%, 7.41%, and 2.06% of the respondents adapted the strategies because of personal interest, other reasons not explained, the presence of the village by-laws and the presence of fines and penalties, respectively. Furthermore, limited access to financial credits, many years of farming experience, lack of relevant climate information, and insufficient social group membership were among the factors that caused farmers not to adapt to drought adaptation strategies in the study area.

From Table 4, the findings have confirmed that smallholder farmers in Kishapu District are already aware of drought conditions and drought-resistant strategies' adaptation. The study results showed that a significant percentage of the study population were aware of the drought and climate change situation in the study area and hence had already adapted to the drought, though they claimed to have an insufficient

Table 4: Drought adaptation Kishapu District Council

Variables	**Criteria**	**Number of Respondent**	**(%)**
Drought adaptation	Respondents adapted to drought	202	84
	Respondents Not adapted to drought	40	16
Strategies knew by smallholders' farmer	Change of planting dates	113	25
	Irrigation	91	20
	Crops variety	155	34
	Move to nonfarm activities	63	14
	Soil conservation	30	7
Strategies used by smallholders' farmer	Change of planting dates	107	24
	Irrigation	62	14
	Crops variety	189	42
	Move to nonfarm activities	70	15
	Soil conservation	24	5
	Practicing crop diversities	70	13
	Move to nonfarm activities	24	4
	Others	93	17
Smallholders' awareness	Aware of the drought resistant crops	231	95
	Not aware of the drought resistant crops	11	5
Drought resistant crops adaptation	Adapted to drought resistant crops	111	46
	Not adapted to drought resistant crops	131	47
Types of resistant crops mostly grown	Sunflower	50	7
	Sorghum	230	35
	Millet	179	27
	Cheackpeace	85	13
	Sweet potatoes	120	18
Reasons for drought adaptation	Presence of village by-laws	18	7.41
	Penalties and fines	5	2.06
	Farmers own interest	55	22.63
	Other reasons	24	9.88
	Low rainfall	141	58.02

Table 4: Drought adaptation Kishapu District Council

Variables	Criteria	Number of Respondent	(%)
Household members social group membership	Household members having group membership	26	11
	Household members NOT having group membership	202	90
Farming experience	Average years household head involved in agriculture activities	14.7	
Household village meetings participation	Household members participating in village meetings	8	3
	Household members NOT participating in village meetings	234	97

Source: Field Survey (2018)

harvest of their products as their average annual income was still low and unpredictable.

A lack of proper farm inputs like the use of unimproved seeds and unreliable markets for outputs are likely to lead to a poor harvest. Farm inputs are paramount to stimulating farmers' adaptation to drought-resistant crops and the use of improved agronomic practices. Farmers require access to a variety of farm inputs to obtain necessary inputs that can enable them not only to adapt but also to increase their output and income from their farming activities. Also, the absence of financially assured and reliable markets for their outputs discourage farmers from engaging in farm activities as they compare production cost and benefits they gate after selling their products. This result is consistent with a study by Komba and Muchapondwa (2015) who argued absence or long distance from farm inputs has a negative relationship with adaptation and also, the study is in line with previous studies by (Sanga *et al.,* 2013; Msongaleli *et al.,* 2015) .

Accessibility to Drought and Climate Change Information

Table 5 shows the accessibility of information to respondents in the study area. The results revealed about 97% of all interviewed had access to information, whereas

Table 5: Accessibility to drought and climate change information

S/N	Variables	Criteria	Number of Respondents	Percentage (%)
1	Communication devices ownership	Mobile phones	119	49
		Radio set	73	30
		Television set	22	9
		Not owning (None)	29	12
2	Access to climate information	Number of household members accessing climate information	235	97
		Number of household members NOT accessing climate information	7	3
3	Household village meetings participation	Household members participating in village meetings	234	97
		Household members NOT participating in village meetings	8	3

only 3% reported not having access to weather and climate information. The findings revealed that mobile phones were the main source of information and communication devices owned by farmers, with 49% of all communication devices. A radio set was the second with 30%, a television set was the third with 9%, whereas 12% of all respondents did not have any communication device.

The findings showed that among the various sources of information available, the farmers mainly depended on radio and other media 37.7%, friends and relatives 26.1%, traditional signs 17.9%, extension officers 16.5%, public notice boards 0.6%, and other sources 1.3% for drought conditions and weather in the study area. Of the interviewed respondents, 3% reported having not participated in the village meetings, whereas 97% reported having participated in the village meeting, which is a place where different weather and climate information is disseminated to villagers or farmers.

Sources of weather and climate information

Figure 3 presents the result on the sources of information the smallholder farmers depended on. It showed that the major source of information was radio (38%), followed by friends and relatives (26%), traditional signs (18%), extension officers (16%), and lastly, public notice boards (1%).

Factors determining drought-resistant strategies adaptation

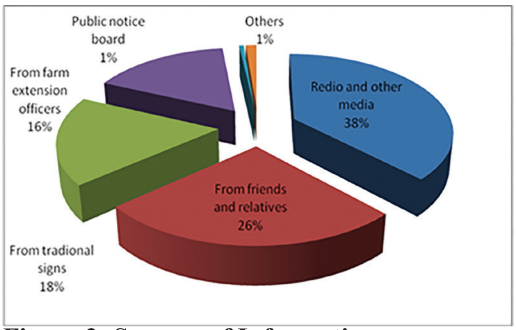

Figure 3: Sources of Information

Table 6 presents the results of factors determining drought-resistant strategies' adaptation. The findings in Table 6 confirmed that household age, access to farming extension services, distance from farm inputs markets, access to information, participation in the village meetings and access to credits are the factors influencing drought-resistant crops in the study area. The Probit regression gave a Pseudo R-square of about 0.7706, suggesting that approximately 77% of the variation in adaptation to drought-resistant crops is explained by the explanatory variables. So, this is an indication that the estimated probit model has integrity; it is appropriate and generally good. The validity of the Probit model in estimating smallholders' farmer adaptation to drought-resistant crops is in line with related studies by Magesa *et al.,* (2023), Hawkins *et al.*, (2022), Msongaleli *et al.*, (2015), Deressa et al., (2009), Komba and Muchapondwa (2015), Nathanel *et al* (2015), Sanga *et al.*, (2013) and Fisher *et al.*, (2015) who used the modal in their studies and came up with significant outcomes.

Household head age had a statistically significant and positive effect on drought-resistant crop adaptation in the study area, as was expected. The positive sign of the age coefficient implies that, holding other variables constant, elderly farmers are more willing to adapt than younger farmers. The findings suggest that elderly farmers make more rational decisions related to drought conditions, possibly due to the long-time experience they have. The marginal effect revealed that as the age of farmers increased by one year, the percentage of adaptation increased by 7.4%. This result complies with findings by Sanga *et al.* (2013) and Deressa *et al.* (2009) who reported similar results that household age has a positive influence on the probability of small-scale farmers' adaptation. However, this finding is in contrast with the findings by Msongaleli *et al.* (2015) and Nathanel *et al.* (2015) who reported a negative relationship between household head age and adaptation.

Distance from farm inputs markets had a negative and statistically significant influence on drought-resistant strategies' adaptation. These findings imply that the long distance from farm inputs markets was less likely to influence adaptation to drought-resistant crops than a short distance from the inputs markets. The reported marginal effect of -0.0358 means that

Table 6: Results of Probit regression model: Dependent variable: Adoption of drought resistant crops

Independent variables	Coefficients	Marginal Effects Dy/Dx
lnAge	1.2644**	0.0743*
	(0.6169)	(0.0416)
lnHHed~s	0.2058	0.0121
	(0.2925)	(0.0158)
lnHous~e	-0.7307	-0.0429
	(0.5517)	(0.0384)
lnTota~e	-0.1954	-0.0115
	(0.2299)	(0.0127)
lnHect~r	0.0702	0.0041
	(0.1695)	(0.0105)
lnExpe~o	0.5791	-0.0340
	(0.3608)	(0.0261)
lnKilo~s	-0.6099***	-0.0358 ***
	(0.1317)	(0.0131)
Villag~s#	2.4716***	0.6466***
	(0.5890)	(0.1869)
Inform~n#	2.0123***	0.4768*
	(0.7347)	(0.2524)
Extens~e#	3.7273***	0.9054***
	(0.6959)	(0.0850)
Access~t#	4.7273***	0.9443***
	(0.6269)	(0.0516)
Market~s#	-0.9225**	-0.1161
	(0.4440)	(0.0971)
Sex#	-0.7680	-0.0317
	(0.6676)	(0.0211)
Farmow~p#	-0.1084	-0.0060
	(0.4773)	(0.0262)
Constant	-11.3024***	
	(4.0756)	
*** represents significant at 1%; ** represents significant at 5%; * represents significant at 10%		
# represent dummy variables		
Number of observations	242	
LR chi²(14)	115.75	
Prob > chi²	0	
Log-likelihood value	-24.88	
Pseudo R- squared	0.7706	

a one-kilometre increase in distance from the farm input markets was likely to decrease the rate of adaptation by 3%, taking other variables constant. The findings from this study comply with the findings by Msongaleli *et al.* (2015); Sanga *et al.* (2013), and Uddin *et al.* (2014). The possible explanation for the increase in distance from input markets is that it discourages farmers from travelling long distances searching for farm inputs. Yet, they are supposed to pay some amount of money to purchase the inputs they need; the higher the distance to the input markets, the lower the rate of adaptation to the production of the drought-resistant crop.

Access to extension services was found to have a positive impact on adaptation to drought-resistant strategies. Holding all other variables constant, farmers with access to extension services are more willing to adapt than farmers with no access to such services. This means extension service access is a strong predictor of adaptation to drought. Therefore, the higher the extension service provision, the higher the rate of adaptation. The extension service marginal effect of the respondents showed that the likelihood of farmers to adaptat to drought increased as more extension services were provided by 0.9054, which is equivalent to about 90%. The possible reasons why farmers with access to extension services do adapt to the production of drought-resistant strategies might be that the education obtained from extension officers does influence and assure them better output. The study is also in accordance with Sanga *et al.* (2013) who, in their study, found a lack of appropriate extension services to be among the limiting factors for farmers' adaptation to drought and climate change in Morogoro Region.

Access to relevant information had a positive and statistically significant effect on drought-resistant strategies' adaptation. The positive sign of the access to relevant information coefficient implies that, holding all other variables constant, smallholder farmers with access to relevant information have a high chance of adapting to drought resistance. The possible explanation for why people with climate and weather information are more likely to adapt to drought-resistant strategies is that having enough information on weather and climate means farmers get encouraged after observing climate and weather trends and so use that as a basis for adapting to new techniques and methods of farming.

Access to financial credits had a significant and positive effect on drought-resistant crop production in the study area. Holding all other variables constant, access to financial credits by smallholder farmers influenced adaptation to drought-resistant crop production more than among farmers with no access to financial credits. The findings further revealed that an increase of 1% in accessibility to farm financial credits increased the chances of adapting drought-resistant crops by 94%. This means that access to financial credit is a key and strong predictor of drought adaptation in the study area; therefore, the higher the accessibility to financial credit, the higher the probability of the farmers adapting drought-resistant crop production. This could be attributed to the fact that individuals with financial credits increase the chances of accessing other farm inputs and capital necessary for adapting to drought resistance strategies. This result is in line with the findings by Komba and Muchapondwa (2015) and Deressa *et al.* (2009) who found that the accessibility to credits does influence the rate and ability of drought adaptation.

Similarly, participation in the village meetings was positive and statistically significant, showing that drought adaptation goes hand in hand with village meeting participation by the household. This conforms to the prior expectation, which can be explained by the fact that farmers participating in village meetings have more chances of adaption to drought and climate changes. The possible reasons are that farmers participating in the village meetings do access to different farming practices and new knowledge thus enabling them to solve challenges they get from their daily farming activities. The marginal effect of participation in village meetings was 0.6466, implying that an increase in one unit of the rate of meetings contributed 65% of chances of adaptation to drought.

Factors influencing choices of adaptation strategies to drought conditions

Table 7 and Table 8 present findings on the multinomial logit model used to determine the socio-economic variables influencing the choice of adaptation strategies to drought and climate change in the Kishapu district.

The findings in Table 7 confirm that household total income, experience in environmental management, distance from the farm inputs markets, access to information, access to extension services and gender of the household are either positively or negatively influenced the choice of adaptation strategies by small-scale farmers in the study area. The findings from Table 7 show that household income had a positive relationship with the choice of soil conservation as an adaptation strategy to drought. This means that as the family household income increased, the probability of farmers choosing soil conservation as the drought adaptation strategy was likely to increase too. The possible argument for this result could be that, given a higher household income, there would be freedom and an increased ability to access different techniques and inputs.

This result complies with findings of previous related studies by Deressa *et al.,* (2009) and Komba and Muchapondwa (2015) who found a positive relationship between higher income and readiness to undertake adaptation strategies. Household experience in the environment, as presented in Table 7 has a positive relationship with the choice of nonfarm activities as the strategy for adaptation to drought and climate change in the study area. This implies that an individual gains more experience in the environment and gets to know the weather and climate change, the more they would like to undertake nonfarm activity as an alternative to drought and climate change.

The possible explanation is that as household head experience increases, the household would not tolerate many years of failures and unsuccessfulness in farming activities, hence opting for nonfarm activities like a business. This result confirms the previous study by Nathanel *et al.,* (2015) who found a negative relationship between the experiences of farmers in an environment and the adoption of an early maturity maize variety in Katsina.

Also, distance from the farm inputs markets (the increase in kilometers away from the farm inputs markets) has both positive and negative influences on the choice of adaptation strategies. The higher distances negatively influence the undertaking of nonfarm activities as the adaptation strategy by farmers in the study area, as presented in Table 7. The increases in the distance do discourage the undertaking of moving from nonfarm activities by 2%, as it limits the alternative strategies for farmers. On the other hand, the increase in distance from the farm input markets does positively influence the selection of soil conservation as a drought adaptation strategy in the study area.

Access to weather and climate information, accessibility to weather and climate information has both positive and negative influences on the selection of different adaptation strategies in the study area. Information positively influences the choice of changing planting dates and Soil conservation strategies are presented in Table 7. This implies that farmers with access to information have a better chance of undertaking these adaptation strategies in the study area than those with no access to such information. Access to information increases the chances of accessing skills and knowledge on how to better adapt to drought and climate change. On the other hand, access to information negatively influences the selection of a variety of crops by farmers with no information. The main reason why people with information hesitate from adapting to new crop varieties is that trials in the traditional mixing of crops have proven failures, so farmers do dislike the option.

Access to farming extension services, the accessibility to farming extension services has a positive relation to the undertaking of changing planting dates by the farmers as shown in Table 7. The knowledge and skills obtained through extension services do positively encourage and motivate farmers to undertake the changing planting dates as part of their adaptation strategies. This implies that extension service is of paramount importance to the choice of relevant adaptation strategies by farmers in the study area.

Table 7: Estimated multinomial logit choice of adaptation strategies

Explanatory variables	Changing planting dates	Irrigation	Crops varieties	Move to nonfarm	Soil conservation
	coefficient	coefficient	coefficient	coefficient	coefficient
lnAge	-0.6588***	0.6055	-0.7203	-0.3029	-2.8270***
	(0.5939)	(1.7268)	(0.6141)	(0.8077)	(0.8515)
lnHHed~s	-0.2444	-0.7597	-0.3689	-0.1983	0.6352
	(0.3215)	(0.5437)	(0.2618)	(0.3504)	(0.3243)
lnHous~e	-0.2449	0.3509	-0.0756	0.0172	-0.0643
	(0.3753)	(0.6954)	(0.4032)	(0.5669)	(0.3648)
lnTota~e	-0.1225***	-1.6023	-0.4352	-0.1742	-0.9902***
	(0.2245)	(0.7283)	(0.2589)	(0.2967)	(0.3069)
lnHectorsnumber	-0.2856	0.0163	0.1796	-0.0014	0.1753
	(0.2499)	(0.3299)	(0.2070)	(0.3334)	(0.2255)
lnExperienceenviro	-0.4323***	-0.4495	0.0846	0.7421	-17.1151***
	(0.4969)	(0.8085)	(0.4495)	(0.4864)	(1.7545)
lnKilometerinputs	-0.1894**	-0.0874	-0.1669	-0.3641	-0.2103*
	(0.1019)	(0.3108)	(0.1150)	(0.1785)	(0.0955)
Villagemeetings	-0.6139***	12.8212***	-0.5169	-0.4881	12.1898***
	(1.3724)	(1.3330)	(0.8167)	(1.2278)	(1.3680)
Information	12.9150***	12.7979***	-2.2623	-1.3811	12.1367***
	(1.0772)	(1.8646)	(1.0964)	(1.3216)	(1.5424)
Extensionservice	1.7299***	-3.0034***	0.4220	0.2582	11.8189***
	(1.5417)	(0.9102)	(0.6438)	(0.9204)	(1.3750)
Accesscredit	0.5889***	0.2606	-0.5961	-0.7107	11.8065***
	(1.5928)	(1.2299)	(0.6313)	(0.7995)	(1.1825)
Marketsaccess	-0.5699***	-0.0128	-0.4617	0.3813	-12.1159
	(1.9447)	(1.4874)	(0.7728)	(0.8706)	(1.1825)
Sex	-0.1927***	1.1144	0.3844	0.9822	13.9272***
	(0.4361)	(0.9354)	(0.4918)	(0.5999)	(1.1489)
Farmownership	-0.1122***	0.3815	-0.7302	-0.2418	13.7342***
	(0.5712)	(1.1954)	(0.5374)	(0.8946)	(1.1157)
_cons	-9.7631***	-7.6411	11.5195***	4.3191	-57. 3519
	(4.0162)	(10.4362)	(4.2315)	(5.2030)	(7.5947)

*** represents significant at 1%; ** represents significant at 5%; * represents significant at 10%

Diagnostic	
Base category	No adaptation
Number of observations	242
LR $chi^2(70)$	4031.29
Log-likelihood value	-295.89281
Pseudo R- squared	0.1131

Table 8: Specification Test for Logit Statistical model

Probit regression	Number of observation	=	242
	LR $chi^2(2)$	=	167.31
	Prob > chi^2	=	0.0000
	_hat	=	0.000
	hatsq	=	0.765
Log likelihood = -24.843075	Pseudo R^2	=	0.765

The gender of the household's head has both positive and negative influences on the choice of the adaptation strategies in the study area. A household headed by a male has a positive relationship in choosing to move to nonfarm activities as an adaptation strategy compared to a household headed by a female when avoiding this particular strategy for drought adaptation. Therefore, this study concludes that the gender or sex of the household head has both positive and negative influences on the choice of different adaptation strategies for drought adaptation. Hence, the study conforms to the study by Deressa et al (2009) who argued that the sex of the household has a significant influence on the adaptation to climate change.

Conclusions

The findings of this study showed that most of the respondents (86%) had already adapted drought conditions and undertaken different adaptation strategies. Thus, people are aware and interested in drought adaptation and, especially the growing of drought-resistant crops in the study area. The main limitations for efficient and effective adaptation to drought in the study area are insufficient farm inputs and proper and timely extension services. Though 89% reported accessing the services, only 24% were very satisfied with the services they were being provided with. Thus, there is room for an increasing adaptation rate and strategies for drought conditions that will later lead to an increase in farm output. The government and other stakeholders should enhance access to market channels for both inputs and outputs as their availability will promote farmers' adaptation to drought. Also, providing timely extension services and relevant information to the small-scale farmers and encouraging the youth to undertake drought-resistant crop adaptation as they seem not to be much involved in drought adaptation in the study area.

From the findings and conclusions, it is recommended that, while providing extension services, it is not mandatory to introduce new crop varieties as long as drought-resistant crops like sorghum, bush millet, and sweet potatoes are still viable if only grown by using improved varieties and methods. So, the most important thing is to introduce the best production techniques and improved seed varieties in order to improve productivity and yields. On the other hand, proper information through relevant channels like village meetings, extension officers, and the media is of crucial importance so as to encourage adaptation to drought-resistant crops in the study area.

Kishapu District Council can improve the mechanisms of extension services provided to the farmers since only 24% of respondents reported being very satisfied with the extension services provided, while more than 50% were either not very satisfied or did not have knowledge of the satisfaction level of the extension services provided by extension workers in the district. Different strategies should be employed so as to enable smallholder farmers to have not only extension services but also better agronomic techniques and proper information on weather and climate trends so that more and more farmers could have better knowledge and skills on drought-resistant crops production and drought adaptation strategies.

Household income, experience, distance from farm inputs markets, access to weather, access to extension, and gender were the main factors influencing the choice of the drought-resistant crop as the drought adaptation strategy in the Kishapu District Council. Therefore, any intervention regarding small-scale farmers' adaptation to drought-resistant crop production should take into consideration these variables so as to get acceptance and achieve the intended purpose. This conclusion informs the implementation of the National Strategy for Mainstreaming Gender in Climate Change (2013) and the National Climate Change Response Strategy 2021-2026 with the overall objective of ensuring that gender considerations are mainstreamed into national policies, programmes, and strategies related to climate change. In addition, these strategies promote the production and integration of traditional weather and climate services for improved warning systems and reducing climatic disaster risks, sustainable production systems and forge sustainable market linkages, access to reliable and quality extension service.

Conflict of interest

The authors declare that they have no conflict of interest.

Authors' contribution

Conceptualization: AEM; JKS; Methodology: AEM, EM; Formal analysis and investigation: AEM; Writing original draft preparation: JSK, EM; Writing, review and editing: JSK, EM; AMK; Supervision. All authors read and approved the final manuscript.

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