Indigenous and Scientific Forecasts on Climate Change Perceptions of Arable Farmers: Rwenzori Region, Western Uganda

Michael Robert Nkuba, Raban Chanda, Gagoitseope Mmopelwa, Akintayo Adedoyin, Margaret Najjingo Mangheni, David Lesolle, and Edward Kato

Contents

M. R. Nkuba (✉) · R. Chanda · G. Mmopelwa · D. Lesolle
Department of Environmental sciences, University of Botswana, Gaborone, Botswana
e-mail: mnkuba@gmail.com; chandar@mopipi.ub.bw; gmmopelwa@mopipi.ub.bw; david.lesolle@mopipi.ub.bw

A. Adedoyin
Department of Physics, University of Botswana, Gaborone, Botswana
e-mail: akintayo_adedoyin@yahoo.com

M. N. Mangheni
Department of Extension and Innovation Studies, College of Agricultural and Environmental Sciences, Makerere University, Kampala, Uganda
e-mail: mnmangheni@gmail.com

E. Kato
International Food Policy and Research Institute, Washington, DC, USA
e-mail: E.Kato@cgiar.org

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Abstract

Despite the dissemination of climate information from national meteorological systems, arable farmers still have challenges of dealing with climate-related risks. This study investigated the effect of using indigenous knowledge-based forecasts (IFs) and scientific knowledge-based forecasts (SFs) on the climate change perceptions of arable farmers in the Rwenzori region, Western Uganda. Data on socio-economic characteristics, use of forecasts, and climate change perceptions was collected from 580 arable farmers and the probit model was used in the analysis. The findings indicated that use of IFs only increased the likelihood of perceiving increase in the frequency in occurrences of droughts and floods. Using both SFs and IFs had a significant positive effect on perception of unpredictable rains and the increase in drought incidence among arable farmers. Although forecasts are important drivers of perceptions, other factors, such as gender, social capital, and dissemination of climate change information by radio, enhance climate change perceptions. Active participation of arable farmers in the dissemination of forecasts by national meteorological services could improve perceptions of climate related risks.

Keywords

Scientific forecasts · Indigenous knowledge · Indigenous forecasts · Climate change perceptions · Arable farmers · Uganda

Introduction

Despite the dissemination of scientific knowledge-based climate forecasts (SFs) by national meteorological systems, arable farmers still face challenges of dealing with climate-related risks. The impact of 1.5 degrees centigrade of global warming will significantly decrease agricultural production and access to water, and increase drought frequency and dry spells in Africa (IPCC 2018a). SFs influence disaster risk perceptions in general and climate change perceptions in particular for arable farmers and pastoralists. The climate change perceptions of arable farmers can influence farmers' adaptation to extreme weather events. Failure to use SFs may have negative effects on the adoption of disaster risk-reduction strategies. Failure to use early-warning information has resulted in loss of property, livestock, crops, and human lives as a result of disasters such as floods and droughts. For example, the floods in Mozambique in 2000 had a huge humanitarian effect on the local communities (Moore et al. 2003). Indigenous and scientific forecasts enhance climate change adaptation strategies of pastoralists (Nkuba et al. 2019b) and arable farmers (Nkuba et al. 2020a). Climate information use can improve the climate change perceptions of arable farmers, leading to better adaptation to extreme weather events and improved resilience to climate-related disasters. There are initiatives that are promoting a co-production of climate information which involves indigenous and scientific forecasts (IPCC 2018b). In this chapter, drought increase refers to increase in frequency and severity of droughts and flood increase refers to increase in frequency and severity of floods.

The most common climate change perceptions among farmers in Uganda include flood increase (Mubiru et al. 2015), drought increase (Cooper and Wheeler 2017; Mubiru et al. 2015; Napa 2007; Okonya et al. 2013), rainfall seasonality change (Cooper and Wheeler 2017; Napa 2007; Okonya et al. 2013; Tiyo et al. 2015), and temperature increase (Mubiru et al. 2015; Napa 2007; Okonya et al. 2013; Tiyo et al. 2015). The perceptions commonly cited in the Rwenzori region include flood increase, drought increase, and rainfall seasonality change (Oxfam 2008; RTT 2011). The use of indigenous knowledge-based climate forecasts (IFs) and SFs influences climate change perceptions in Uganda (Napa 2007; Waisswa and Otim 2012). In spite of high or widespread access to SFs due to the proliferation of radio stations in Uganda's rural areas (NAPA 2007), the use of IF is still high (Napa 2007; Okonya and Kroschel 2013). The spatial location of the Rwenzori, region combined with relief features such as Mount Rwenzori, forested areas, and flood plains in lowlands, makes it vulnerable to extreme weather events (Oxfam 2008; RTT 2011). Research in Uganda has shown that agro-ecological zones have an influence on climate change perceptions (Mubiru et al. 2015; Okonya et al. 2013; Tiyo et al. 2015). Climate-related disasters that occur in Uganda include droughts, floods (Oxfam 2008), landslides, temperature increase, and rainfall seasonality change (Napa 2007). Therefore, this chapter has taken into account agro-ecological zones.

Farmers' use of IFs as a source of climate information influences their climate change perceptions. The literature shows that IFs have influenced the livelihoods of farmers globally. Such influence has, for instance, been reported in Australia (Green et al. 2010), West Africa (Nyong et al. 2007; Roncoli et al. 2002), East Africa (Speranza et al. 2010), Southern Africa (Kalanda-Joshua et al. 2011; Kolawole et al. 2014; Motsumi et al. 2012), Samoa (Lefale 2010), New Zealand (King et al. 2008), the Artic (Pennesi et al. 2012), Mongolia (Andrei 2010), British Colombia in Canada (Gearheard et al. 2010), and Asia (Galacgac and Balisacan 2009). IFs have influenced the choice of crop enterprises among arable farmers.

Climate change perception studies using econometric models to analyze the effect of climate information have produced mixed results. A study done in Kenya revealed that climate information positively and significantly influenced farmers' climate change perceptions (Ndambiri et al. 2013). However, while several other studies (Gbetibouo 2009; Silvestri et al. 2012; Tesfahunegn et al. 2016) have reported that climate information positively influenced climate change perceptions, the influence was not statistically significant. In fact there are also studies (Bryan et al. 2013; Gbetibouo 2009) that have reported that climate information negatively influenced farmers' perceptions. Thus, there seems to be a lack of unanimity about the direction of influence that climate information has on farmers' perceptions of climate change risks. Most of the literature does not specify whether farmers used IFs or both IFs and SFs. In fact, there is little literature on the influence of IF only or of both SF and IF on climate change perceptions of arable farmers and pastoralists.

Table 1 Explanatory variables for climate change perceptions

Description	Expected sign	Cited literature
Age	–	Habtemariam et al. (2016), Tesfahunegn et al. (2016)
Farm experience	+	Bryan et al. (2013), Gbetibouo (2009), Silvestri et al. (2012), Thi Lan Huong et al. (2017)
Education level	+/–	Gbetibouo (2009), Habtemariam et al. (2016), Maddison (2006), Silvestri et al. (2012), Thi Lan Huong et al. (2017)
Gender: : male, female	+/–	Bryan et al. (2013), Silvestri et al. (2012), Thi Lan Huong et al. (2017)
Access to institutions: Credit access, agricultural extension access, improved crop varieties access, non-farm access, hired labor access	+/–	Bryan et al. (2013), Gbetibouo (2009), Habtemariam et al. (2016), Silvestri et al. (2012), Tesfahunegn et al. (2016), Thi Lan Huong et al. (2017)
Use of climate information: use of IF only, use of both IF and SF	+/–	Bryan et al. (2013), Gbetibouo (2009), Lybbert et al. (2007), Silvestri et al. (2012), Tesfahunegn et al. (2016), Thi Lan Huong et al. (2017)
Agro-ecological area: lowland, mountainous and forested, forested, mountainous	+/–	Chingala et al. (2017), Deressa et al. (2008)
Farm size	+/–	Gbetibouo (2009), Habtemariam et al. (2016), Tesfahunegn et al. (2016)
Sources of climate change information: radio, newspaper, fellow farmer, IK old farmer	+/–	Deressa et al. (2008), Habtemariam et al. (2016)
Access to government programs on climate change	+	Silvestri et al. (2012)

Source: Authors specification

Studies have also shown that there are a number of other factors that influence climate change perception (Table 1). These include household background factors such as farm experience, age, gender, education level, livelihood choices, farm income, and institutional factors such as agricultural extension, market access, access to credit, access to farm organizations and location-specific factors (Chingala et al. 2017; Deressa et al. 2008; Gbetibouo 2009; Habtemariam et al. 2016; Maddison 2006; Silvestri et al. 2012; Tesfahunegn et al. 2016). Climate change perception studies that included climate information in their analysis (Gbetibouo 2009; Ndambiri et al. 2013; Silvestri et al. 2012; Tesfahunegn et al. 2016) did not take into account the difference between the use of IFs and SFs, which this study has done. Studies on climate change perception have revealed that arable farmers' perceptions include drought increase, flood increase, rainfall season change, temperature increase, unpredictable rainfall increase, and rainfall decrease (Chingala et al. 2017; Deressa et al. 2008; Gbetibouo 2009; Maddison 2006; Nhemachena and Hassan 2007; Silvestri et al. 2012).

The above review of related previous studies demonstrates several realities that (a) climate information influences farmers' climate change risk perceptions but with mixed results as to the direction of influence; (b) there are other factors that may have a bearing on farmers' perceptions of climate-related risks; and (c) there is a paucity of literature on the relative influence of IFs only and/or of IFs and SFs on farmers' perceptions of climate-related risks. This study thus contributes to ongoing efforts and debate regarding the influence IFs as well as IFs and SFs on arable farmers' perceptions of climate-related risks in the Rwenzori region of Western Uganda by addressing the question "Do IFs and/or SFs influence climate change perceptions of arable farmers?" Overall, this study contributes to the climate change perception literature that relates to the influence of the use of indigenous knowledge forecasts and scientific climate forecasts on the behavior of arable farmers in Africa, in the Rwenzori region of Uganda. It also suggests what the implications are of access and use of climate information on climate change perceptions of farmers. The scope of this chapter addresses the effect of climate information on climate change perceptions of arable farmers in Western Uganda and does not cover pastoralists.

Materials and Methods

The Study Area

In the Rwenzori region of Western Uganda where the study was done (Fig. 1), farmers have reported perceiving evidence of climate change such as rains becoming more unpredictable, drought increasing in frequency and intensity and floods becoming more frequent and disastrous (Oxfam 2008). Agro-ecological zones include mountainous, lowland, mountainous and forested, wetland, and forest (Fig. 1). This agro-ecological diversity makes the Rwenzori region a good case study area for investigating how local agro-ecology influences climate change perceptions. The various agro-ecological zones are spread over the districts of Kabarole, Kyegewa, Kyenjojo, Ntoroko, Kamwenge, and Bundibugyo within the Rwenzori region and Kibale in the adjoining Bunyolo region (Fig. 1). Because this region is endowed with fauna and flora of wildlife-protected areas such as Queen Elizabeth, Kibale, Semi-liki, and forested protected areas, the use of IFs is highly prevalent (Nganzi et al. 2015). Although access to SFs is high due to the proliferation of FM radio stations in Uganda (Jost et al. 2015), the use of SFs is not very high (Okonya and Kroschel 2013). Arable farming is a major source of livelihood. Rwenzori region is a multiethnic society, with many tribes whose rural livelihoods are influenced by indigenous knowledge systems. There is high variability in the onset of rains in Rwenzori region (Nkuba et al. 2019a). Indigenous forecast indicators are commonly used as sources of climate information (Nkuba et al. 2020b).

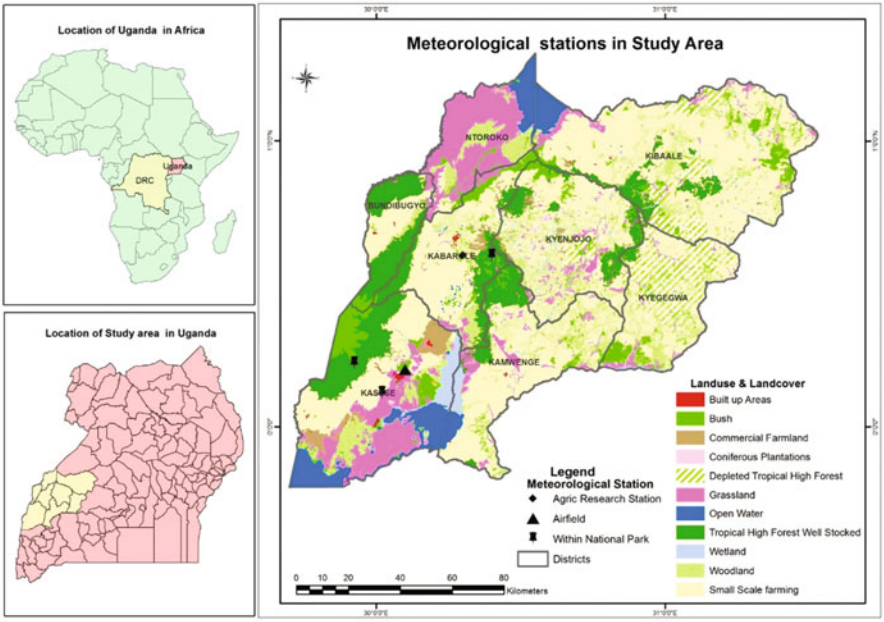

Fig. 1 Location map of study area

Sample Size, Data Collection, and Analysis

A two-stage stratified sampling approach (Cochran 1963) was employed to select the respondents. Farming systems and agro-ecosystems including mountainous, lowland, forested, wetland, and mountainous and forested formed the basis for the strata. The first stage units were the local agro-ecological systems, and the second-stage units were households. The statistically selected sample size of farmers was allocated to the selected districts using proportional allocation to size, where the size represents the number of households in a particular subcounty in the selected district. Based on a population of the study area of 102,496 households according to the 2014 Uganda population census report, a sample size of 778 was randomly selected with 95% confidence level and a margin of error of 3.5%. To allow for replacement in the sample of those who might back out of the study, a 19% of the statistically selected sample was included giving a total study sample of approximately 924. This was also to ensure good sized subsamples (for those who use IF and SF, and IF only). After data cleaning, 17 incomplete questionnaires were eliminated from the final analysis. The total sample size was therefore 907, and of these 580 were arable farmers, 269 were pastoralists, and 57 were agro-pastoralists. This chapter limits itself to the 580 arable farmers.

A household survey conducted from August to October 2015 was used to gather data through a face to face administered questionnaire on climate change perceptions, household characteristics, and climate information use. Pilot testing of the questionnaire translated into the local language was done before the household survey to ensure both content and measurement validity, and the local languages were used by trained research assistants. Data was analyzed using Stata 12 statistical software. The probit model was used in the analysis.

Empirical Model

Various econometric models have been used in climate change perception studies such as the probit model (Gbetibouo 2009; Maddison 2006), the logistic model (Silvestri et al. 2012; Tesfahunegn et al. 2016), the multinomial logit model (Bryan et al. 2013), and the Heckman probit selection model (Deressa et al. 2008; Ndambiri et al. 2013). For this study, the probit model was used in the analysis.

The empirical model is specified as follows:

$$Y_{ij} = f\ (H, I, A, W, S, G, U,) + \varepsilon \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

where Y_{ij}(j = 1,2,3,4,5,) representing the climate change perceptions of farmers [$Y_{1i} = 1$, if drought increase (0 otherwise). $Y_{2i} = 1$, if floods increase (0 otherwise) $Y_{3i} = 1$, if unpredictable rains (0 otherwise)$Y_{4i} = 1$, if rainfall seasonality change (0 otherwise) $Y_{5i} = 1$, if temperature increase (0 otherwise)].

Household characteristics (H): the level of education, age, gender, and farming experience; use of climate information (U): use of IF only, use of both IF and SF; institutional characteristics (I): access to agricultural extension, access to improved crop, credit, and nonfarm resources; agro-ecological area (A): forested, lowland, mountainous, wetland, mountainous, and forested; wealth (W): farm size; sources of climate change information (S): radio, fellow farmer, old IK farmer, newspaper; access to government program climate change interventions (G). The expected signs for the variables are indicated in Table 1.

Results

Socio-Economic Characteristics of Arable Farmers

The descriptive characteristics show that respondents were mostly male (Table 3), of average age 46 years. The average farm size was 7.95 acres. Arable farmers mainly used the forecasts for predicting onset and cessation of rains (Tables 2). Majority of the arable farmers attained primary level of education (Table 3). The most common climate change perceptions were rainfall seasonality change and unpredictable rains (Table 4). Radio was a very important source of climate change information (Table 5).

Table 2 Arable farmers' use of indigenous and scientific forecasts in the Rwenzori region

	Onset (%)		Cessation (%)		5-day (%)		Seasonal (%)		
	Full sample	Subsample	Full sample	Subsample	Full sample	Subsample	Full sample	Subsample	% of Full Sample
IF and SF	38	77	33	65	27	54	19	38	50
IF only	49	100	48	96	41	83	34	69	49

Source: Survey data 2015. Full sample = 580, IF and SF = 289, IF only =287

Table 3 Household characteristics of respondents

Variable	Variable definition	Arable farmers (N = 580)
Male	Gender of the household head (1 if female)	0.54
Female	Gender of the household head (1 if female)	0.46
No school	No formal education (1 if yes)	0.24(0.43)
Primary	Primary education (1 if yes)	0.53 (0.5)
O-level	Ordinary secondary education (1 if yes)	0.18(0.39)
Higher educ	Advanced secondary education or diploma (1 if yes)	0.04(0.18)
Secondary educ	Ordinary or advanced secondary education (1 if yes)	
Tertiary educ	Certificate, university education(1 if yes)	0.01(0.08)
Age(years)	Household head age (completed years)	45.54(14.17)
Farming exp	Farming experience (completed years)	24.11(13.72)
Farm size	Farm size owned(acres)	7.95(25.09)
Herd mobility	Herd mobility (1 if yes)	
Forest	Reside forested areas (1 if yes)	0.21(0.41)
Mountain	Reside in mountainous area (1 if yes)	0.17(0.37)
Wetlands	Reside in wetland area (1 if yes)	0.14(0.35)
Lowlands	Reside in lowland area (1 if yes)	0.34(0.47)
Mountainous and forested	Reside in mountainous and forested area (1 if yes)	0.14(0.35)

Source: Survey data 2015. Figures in parentheses are standard deviations

The Effect of Forecast Use on Climate Change Perceptions of Arable Farmers and Pastoralists

The results show that the use of both IFs and SFs or IFs only has a positive effect on the climate change perceptions of arable farmers (Tables 6 and 7). Arable farmers using IFs only were more likely to perceive drought increase by 22% and flood increase by 8%. Arable farmers using both (IFs and SFs) were more likely to perceive unpredictable rains by 18% and drought increase by 18%. There are peculiarities in the effect of forecast use on climate change perceptions. Five-day forecasts had a negative influence on the climate change perceptions of arable farmers (Tables 6 and 7). This suggests that arable farmers do not have much confidence in short range forecasts with regard to their perceptions of risks associated with extreme weather events. The use of both IF and SF for onset of rains had a negative influence on arable farmers' perceptions of climate-related risk (Table 7). This could be due to variability in rainfall onset prediction.

Table 4 Climate variability and change perceptions and access to institutions

Variable	Variable definition	Arable farmers (N = 580)
Temp increase	Temperature increase (1 if yes)	0.22(0.42)
Rainfall seasonality change	Rainfall seasonal change (1 if yes)	0.49(0.5)
Droughts increase	Droughts increase (1 if yes)	0.21(0.41)
Floods increase	Floods increase (1 if yes)	0.11(0.31)
Unpredictable rains	Unpredictable rains (1 if yes)	0.51 (0.5)
Credit access	Credit access (1 if yes)	0.42(0.49)
Improved crop access	Improved crop access (1 if yes)	0.41(0.49)
Nonfarm access	Non-farm access (1 if yes)	0.23(0.42)
Agricultural extension access	Agricultural extension access (1 if yes)	0.11(0.32)
Access govt climate change adaptation interventions	Access to govt climate change adaptation interventions (1 if yes)	0.26(0.44)

Change in onset and cessation of rains
Source: Survey data 2015. Figures in parentheses are standard deviations. There were multiple responses for perception of climate variability and change

Table 5 Sources of climate change information

Variable	Variable definition	Arable farmers (N = 580)
Farmer organization	Farmers organization as source of climate change information (1 if yes)	0.13(0.33)
Fellow farmer	Fellow farmers as source of climate change information (1 if yes)	0.18(0.38)
Old IK farmer	IK old farmers as source of climate change information (1 if yes)	0.22(0.42)
Radio	IK old farmers as source of climate change information (1 if yes)	0.52(0.50)
Newspapers	IK old farmers as source of climate change information (1 if yes)	0.03(0.16)

Source: Survey data 2015. Figures in parentheses are standard deviations

The Effect of Other Factors on the Climate Change Perceptions of Arable Farmers

Agro-ecology zones increased the likelihood of arable farmers perceiving climate change risks (Tables 6 and 7). Being resident in mountainous areas increased the likelihood of perceiving rainfall seasonality change by 22%. Rainfall seasonality change was more likely to be perceived by famers using both (SF and IF) in forested areas by 13%, wetland areas by 21%, and lowland areas by 18% (Table 7). Rainfall seasonality change was more likely to be perceived by famers using IF only in forested areas by 14%, wetland areas by 23%, and lowland areas by 19% (Table 6). Drought increase was more likely to be perceived by famers using both (SF and IF) in forested areas by 17%, mountainous areas by 15%, wetland areas by 29%, and

Table 6 Marginal effects of climate change perceptions for arable farmers who use if only

Variable	Rfall seasonal change	Drought increase	Floods increase	Unpredictable rains
IF only for onset		0.216***(0.068)		−0.279*(0.162)
IF only for cessation			0.078***(0.025)	0.267(0.162)
IF only for 5 day	0.094*(0.049)	−0.259***(0.049)		
IF only for seasonal		0.121**(0.061)		
Farm size	0.004(0.002)			
Forest	0.141*(0.077)		−0.055**(0.023)	
Mountain	0.215***(0.077)			
Wetland	0.225**(0.081)	0.087*(0.056)	−0.056*(0.024)	
Lowland	0.190**(0.074)		−0.036(0.024)	
Agri-ext access		0.064(0.059)	−0.083**(0.020)	
Farmer org access	0.227***(0.056)	0.146***(0.053)		0.159***(0.057)
Credit access	0.184***(0.048)			0.077*(0.046)
Non-farm access				0.179***(0.051)
Female	0.064(0.050)			
Male		0.079**(0.033)		
No school	−0.345**(0.143)		−0.064**(0.021)	0.272*(0.141)
Primary	−0.324**(0.151)			0.286*(0.145)
Sec educ	−0.338**(0.142)			0.353**(0.125)
Farm experience	0.002(0.002)			
Age		−0.002(0.001)		
CC info from elderly farmer	0.277***(0.051)			0.158***(0.051)
CC info from radio		0.133***(0.034)		−0.132***(0.045)
CC info from fellow farmer		−0.097**(0.040)		−0.171***(0.062)

Table 7 Marginal effects of climate change perceptions for arable farmers who use both

Variable	Rfall seasonal change	Drought increase	Floods increase	Unpredictable rains
Both only for onset				−0.208** (0.085)
Both only for cessation	−0.093*(0.050)			0.181**(0.086)
Both only for 5 day		−0.223*** (0.031)	−0.058** (0.022)	
Both only for seasonal		0.180*** (0.065)		0.217*** (0.060)
Farm size	0.004*(0.002)			
Forest	0.130*(0.076)	0.167** (0.077)	−0.078*** (0.025)	0.055(0.054)
Mountain	0.215*** (0.076)	0.151** (0.084)	−0.040 (0.027)	0.079(0.061)
Wetland	0.205**(0.082)	0.286*** (0.096)	−0.074** (0.022)	
Lowland	0.175**(0.074)	0.191*** (0.074)	−0.067** (0.026)	
Agri-ext access		0.071(0.060)	−0.089** (0.019)	
Farmer org access	0.231*** (0.055)	0.121** (0.054)		0.168*** (0.057)
Credit access	0.182*** (0.048)			0.066(0.046)
Nonfarm access				0.189*** (0.051)
Female	0.063(0.050)			
Male		0.073** (0.033)		0.052(0.045)
No school	−0.329** (0.145)			
Primary	−0.333** (0.152)			
Sec educ	−0.340** (0.143)			0.072(0.056)
Age		−0.002 (0.001)		
CC info from elderly farmer	0.275*** (0.051)			0.176*** (0.051)
CC info from newspapers		0.177(0.135)		
CC info from radio		0.076** (0.035)		−0.133*** (0.045)
CC info from fellow farmer		−0.104** (0.037)		−0.185*** (0.061)

***, **, and * denote that significance at the 1%, 5% and 10% levels respectively lowland areas by 20% (Table 7). Agro-climatic risks, such as pest and disease prevalence, land degradation due to soil erosion, water stress, climate-related extreme events such as floods and droughts, are influenced by the agro-ecosystem. The results indicate the importance of agro-ecological zones in climate change perception studies. Failure to consider agro-ecological zones in climate change adaptation programs and policies can lead to poor adaptation. The findings also reveal that gender increased the likelihood of arable farmers perceiving climate change (Tables 6 and 7). Being male increased the likelihood of arable farmers' perceptions of drought increase by 7%. Men influence the choice of crop enterprises in farming households based on their climate change perceptions. A participant in a focus group discussion (FDG) reported that "now there is when you want to sow groundnuts but because of the early onset of the rains before you have planted then you plant maize instead." There are mixed results regarding the effect of agricultural extension on climate change risk perception. Agricultural extension access decreased the likelihood of pastoralists' perceptions of drought increase but increased the likelihood of perception of temperature increase. It is plausible that agricultural extension is the source of information on temperature increase received in the 10-day forecasts from the Uganda National Meteorological authority. Agricultural extension access decreased the likelihood of arable farmers' perceptions of flood increase by 8%. This suggests that agricultural extension is not effective in reducing risk attitudes associated with floods.

The results further indicate that access to credit and farmers' organizations increased the likelihood of arable farmers perceiving rainfall seasonality change by 18% and 23%, respectively. This suggests that access to credit contributes to rainfall seasonality change risk perception. The results further indicate that access to farmers' organizations increased the likelihood of arable farmers perceiving drought increase by over 11% and unpredictable rains by 16%. This suggests that social capital contributes to risk perception.

The study shows that access to nonfarm enterprises had a significant positive influence on climate change perception. Access to nonfarm enterprises increased the likelihood of arable farmers' perceptions of unpredictable rains by 18%. This could be attributed to arable farmers reinvesting their nonfarm incomes in agricultural technologies which are climate sensitive (Farmers tend to invest in agricultural inputs, hiring labor (Reardon et al. 1994)). The study also shows that there are mixed results regarding the effect of climate change information (depending on the source) on climate change risk perceptions. For instance, on the one hand, access to radio had positive effect on climate change risk perceptions. Climate change information from listening to radio also increased the likelihood of perceiving drought increase by arable farmers by 13% for those who use IF only and 7% for those who use both. This implies that radio is an effective dissemination mechanism for climate change information.

On the other hand, climate change information gained from fellow farmers negatively influenced climate change risk perceptions by more than 17% (Tables 6 and 7). This could be due to inadequate information about climate change. A participant in an FGD reported not having information on climate change. This calls for capacity building in farmer-to-farmer networks, with climate change messages inserted in agricultural extension interactions. Climate change information given by elderly farmers had a positive effect on perceptions of change in rainfall seasonality by more than 15%. Elderly farmers accumulate knowledge and improve their risk attitudes towards climate-related risk over time. Estimation of temperature increase involves consideration of maximum and minimum temperatures over long periods of time, which meteorologists calculate using models created by statistical software.

This study has established that the source of climate change information matters in arable farmers' perceptions of climate-related risks. The study produced mixed results regarding the effect of education on climate change risk perceptions (Tables 6 and 7). On one hand, education was inversely related to the perception of increase in rainfall seasonality change among farmers, and on the other, education seemed to have a positive influence on arable farmers' perceptions of an increase in the unpredictability of rainfall. This suggests that irrespective of level of education, changes in the onset and cessation of rains are not easily perceived by farmers. This could be due to the effect of climate variability on onset of rains. A key informant reported that onsets of rains were highly variable.

Discussion

The study findings reveal that being male, climate information, access to agricultural extension positively influenced perceptions of drought increase among arable farmers, which is consistent with study of Vietnamese farmers undertaken by (Thi Lan Huong et al. 2017). However, the study also shows that there are mixed results regarding the effect of agricultural extension on climate change risk perception, which is in agreement with earlier studies that showed a positive effect (Bryan et al. 2013; Deressa et al. 2008; Gbetibouo 2009; Opiyo et al. 2016) and others that showed negative effect (Silvestri et al. 2012). Research shows that agricultural extension is a dissemination mechanism for climate information and climate change information (Deressa et al. 2008; Gbetibouo 2009; Opiyo et al. 2016). Bryan et al. (2013) indicated that agricultural extension positively influenced perceptions of temperature increase among arable farmers in Kenya, but Nkonya et al. (2015) reported that agricultural extension in Uganda and Nigeria was weak in disseminating climate change information, making it less relevant in improving the resilience of farmers to climate-related risks. This is consistent with the study's findings that show that access to agricultural extension negatively influenced perceptions of flood increase among arable farmers.

The results show that using IF only positively influenced perceptions of flood increase among arable farmers which is consistent with Thi Lan Huong et al. (2017) who reported that climate information had a positive effect on Vietnamese farmers' perceptions of flood increase.

The results show that the use of both IF and SF has a positive effect on arable farmers who perceive unpredictable rains, which is consistent with Bryan et al. (2013), indicated that SF positively influenced farmers' perceptions of rainfall variability. The findings reveal that credit access increased the likelihood of arable farmers' perceptions of climate change, which in agreement with an earlier study by Silvestri et al. (2012). The study revealed that climate change information from radio increased the likelihood of perceiving drought increase by arable farmers which is consistent with Deressa et al. (2008); Habtemariam et al. (2016), who indicated that climate change information had a positive effect on perception. The study shows that there are mixed results about the effect of education on climate change perceptions which is in agreement with earlier studies that showed a positive effect (Bryan et al. 2013; Deressa et al. 2008; Habtemariam et al. 2016; Ndambiri et al. 2013; Opiyo et al. 2016; Silvestri et al. 2012; Tesfahunegn et al. 2016; Thi Lan Huong et al. 2017) and others that showed negative effect (Gbetibouo 2009; Piya et al. 2012). Research has shown that education increases access to information that improves farmers' resilience to climate-related risks (Opiyo et al. 2016). The study established that irrespective of the level of education, changes in onset and cessations of rains are not easily perceived by arable farmers. Research has shown that there is high variability in onset of rains in Kenya (Recha et al. 2012), Botswana (Byakatonda et al. 2018), and South Africa (Moeletsi and Walker 2012) making an accurate prediction of start of rains a hard undertaking for national meteorological services.

The study reveals that access to farmers' organizations increased the likelihood of arable farmers perceiving climate change which is in agreement with earlier studies (Piya et al. 2012; Tesfahunegn et al. 2016). The study shows that there are mixed results regarding the effect of nonfarm access on climate change perception, which is consistent with earlier studies (Silvestri et al. 2012) that showed a positive effect and others that showed a negative effective effect (Deressa et al. 2008; Ndambiri et al. 2013; Opiyo et al. 2016; Piya et al. 2012; Tesfahunegn et al. 2016). Nonweather dependent ventures such as small and medium enterprises may have a negative effect on arable farmers' perceptions of climate-related risks, while climate sensitive ventures such as livestock and crop sales have a positive effect on perceptions (Opiyo et al. 2016). Deressa et al. (2008) have indicated that nonfarm incomes may contribute to making high-income farmers less risk averse.

The study shows that agro-ecological zones increased the likelihood of arable farmers perceiving climate change which is consistent with Deressa et al. (2008), who reported that being resident in highlands had a positive effect on farmers' perceptions of climate change. Other scholars (Fadina and Barjolle 2018; Gedefaw et al. 2018) have also reported the influence of agro-ecology on perceptions of climate-related risks.

Conclusion

The study has established that the use of scientific and/or indigenous knowledge-based forecasts had varying influence on the perception of climate-related risks among arable farmers in the study area. Specifically, the study has revealed that use of IF only increased the likelihood of perceiving climate change as drought increase and flood increase. The use of both SF and IF positively influenced the perceptions of unpredictable rains and drought increase by arable farmers. The study has proven that SF complements IF in arable farmers' perceptions of climate change. The study has established that the source of climate change information matters in farmers' perception of climate-related risks. The study highlights the importance of forecast information sourced from indigenous knowledge systems and meteorologists regarding farmers' perceptions of climate-related risks under rain-fed agriculture. This therefore underscores the need for the integration of indigenous knowledge forecasts with the national meteorological services. Although forecasts are an important aspect of equipping farmers with information that will help them perceive climate change, the results of this study show that the direct impact of forecasts in enhancing farmer perceptions is limited to specific risks. Therefore, climate information, although necessary, is not sufficient; other factors are also important. Gender, social capital, and radio dissemination of climate change information require special attention when developing and implementing strategies for improving resilience to climate-related risks in rural livelihoods. The active participation of arable farmers and pastoralists in forecast dissemination by National meteorological services would improve farmers' perceptions of climate-related risks.

Lessons Learnt

Indigenous forecasts and scientific forecasts enhance arable farmers' perceptions of climate change. Indigenous knowledge systems play an important role in climate-related risk perception. Factors such as gender, social capital, and dissemination of climate change information by radio improve climate change perceptions.

Future Prospects

An increase in infrastructural investment in meteorology would improve farmers' perception of climate-related risks. This would investment would increase the precision of meteorological forecasts by having a higher meteorological density at district level, consequently improving the early-warning system of climate-related disaster risks.

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