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Climate Variability and Crop Yields in Uganda

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ABSTRACT This paper uses the Uganda National Panel Survey (2013) to examine the impact of climate variations on household crop yields. The findings indicate that average rainfall and average temperature, education level of household head, participation in the National Agricultural Advisory Services programs, the size of cultivated land, use of fertilizers, planting of high breed seeds and use of irrigation significantly increases mean crop yields and reduces the variability of crop yields. In addition, drought and floods significantly reduce mean crop yields and increase crop yield variance. The findings indicate that there need for government and other stakeholders to empower farmers through training, facilitation and networking through the designated offices across the country, on-farm development of technical innovations, removal of critical production to ease and increase access to basic farm inputs to farmers in order to enhance household farm productivity.

INTRODUCTION

The impact of weather variability on agricultural productivity has attracted considerable attention in recent agricultural development literature (IPCC 2007), in spite of its central role in world food production and security. Gregory et al. (2005) and Climate Change (2007) show that longer and more frequent drought spells, rising temperatures, as well as heavier and erratic rains impact ecosystems and human development. Hoffmann (2013) and Benhin (2006) note that heavier rains and persistent droughts increase soil erosion and vegetation damage through run off, while prolonged droughts and increasing temperatures create favourable conditions for pests and diseases to multiply. The primary impacts of climate change are expected to be more manifest in low agriculture productivity that depends directly on favourable climate outcomes (McCarthy et al. 2001; Yengoh et al. 2010). The exposure to risk from climate change and the associated threat it poses to livelihood sources especially in poorer parts of the world have differential impacts on men and women.

Schellnuhuber et al. (2006) warned that if human activities do no slow down the speed of destroying the environment and adapt to climate change, human will face huge damages in agriculture, human health, the economy, and ecological system in the 21st century. IPCC (2007, 2014) pointed out that the distribution of climate variables such as temperature, precipitation, wind speed, and water vapour in the air has significant impacts on agriculture productivity. That is, author notes that essentially, various extreme weather events can affect agriculture productivity. The severe weather has becomes a normal phenomenon in recent years due to climate change, the influence of climate generates many unpredictable effects in the crop production.

In Uganda, the agriculture sector employs over 70 percent of the labour force and contributes about 25 percent of the country's GDP (UBOS 2015). Also it is a source of raw materials used in several processing industries as well as a source of foreign exchange earnings for the country. However, over the past years agricultural productivity growth has been below expectation. How much one can hold climate change responsible for changes in agricultural productivity in Uganda remain unknown. Hence, vulnerability to climate change and weather variability are of particular interest to both researchers and Policy makers. Attempts to analyse the effects of climate change on crop productivity globally have basically focused on mean crop yields using crop simulation model and regression techniques. A number of studies have analysed the impact of climate change on yield variability (Chen et al. 2004; Isik and Devadoss 2006; Finger and Schmid 2007; Wang et al. 2009; Hassan, 2010; Shrestha 2012; Eyshi et al. 2014). To the best of our knowledge, however, there is no similar study on Uganda based on household analysis in a panel framework. To fill this gap, this study intends examine the impact of climatic variability on mean and variance crop yields in Uganda using micro data.

UBoS (2010, 2012) notes that about 24.5 percent of Ugandans are poor and by 2014, 19 percent of Ugandans still lie under poverty and face its detrimental effects. UBoS (2010) further notes that the challenge is that still 75 percent of Ugandan derive their livelihood from rain-fed agricultural related activities. Due to poor rains, 46 percent of Ugandan households registered reduction in food availability largely due to drought (Ssewanyana and Kasirye 2012) and food shortage has resulted in changing their food diet as one of the copping mechanism.

Uganda's agriculture is subsistence, rain-fed and, therefore, vulnerable to climate variability and climate change (LTS International 2008; Hisali and Kasirye 2008). UBOS (2010) notes that Uganda has experienced erratic rain seasons in the past few years with floods leading to waterlogged fields or washing away of crops. Uganda government started The National Agricultural Advisory Services (NAADS 2000) as a semi-autonomous body as a measure to mitigate adverse impacts of climate variability by increasing the efficiency and effectiveness of agricultural extension services to farmers and implemented through the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF). It is mandated to develop a demand-driven, farmer-led agricultural service delivery system targeting subsistence farmers.

The contribution of agriculture to GDP reduced from 52 percent in 1992/93 to 25 percent in 2009/10 (Background to the Budget, 1994/95 and 2009/10), though the sector still employs about 77 percent of the rural population and accounts for more than about 60 percent of the merchandise exports. Hisali and Kasirye (2008) note that up to 34 percent of crop damage in the country is caused by climate related variability. The frequent and intensity of extreme weather events in form of heavy rainfall have resulted in flash floods and floods hence causing outbreak of water borne-diseases such as diarrhoea and cholera, while prolonged dry spells have resulted in outbreak of respiratory diseases (Buyinza and Bbaale 2010).

Therefore, against this background, the paper analyses the impact of weather-variability on crop yields in Uganda using national Panel Survey. The study seeks to provide answers to the following questions: Does household participation in NAADS programs affect crop yields? What is the impact of weather variability and other socioeconomic factors on mean crop yields and yield variability taking into account gender of household head for the three main crops in terms of maize equivalent per acre.

The results of this paper not only contribute to the body of knowledge considering the changing nature of the weather and the socio-economic environment but also inform policy makers and other stakeholders on the different effects of climate shocks on mean crop yields and yield variability at household level. The findings consider the effect of this change upon changing weather conditions in Uganda and its impact on crop yields. This study improves on the previous work on Uganda by employing panel data econometrics, which is more appropriate for the analysis of household productivity (Just and Pope 1978, 1979; Isik and Devadoss 2006; Challinor and Wheeler 2008). In addition, the present study undertook a gender disaggregation to ascertain whether there are any discernible differences in male-headed and female-headed households crop yields. The results show that weather variability has a large effect on mean crop yields and explains a large part of household crop yields among farmers. The effect of background factors such as age of household head, education level of household head, participation in NAADS programs, use of fertilizers, high breed seeds and irrigation as well as other farm related inputs.

In Section 2, the researcher presents the study methodology, Section 3 presents the study findings and Section 4 discusses the study findings, while Section 5 provides concluding remarks and the last section presents the emerging policy recommendations.

METHODOLOGY

In line with Uganda's government policy of climate change, farmers are supported with drought resistant and high yielding crops under the NAADS program. Data analysis involved assessing mean and variance of crop yields for the NAADS participating farmers and non-NAADS participating farmers in a gender perspective. The analysis involves linking households who have experienced changes in climate variations with information on crop yields using descriptive statistics and compared them with those who did not. In addition, the researcher employs the Just and Pope production function to provide more rigorous evidence on the impact of weather variables and selected covariates on crop yields in Uganda.

Model of Climatic Variability on Household Crop Yields

In order to determine the effects of weather variability and socio-economic factors on both the average and variability of crop yield in Uganda, the Just and Pope (1978, 1979) stochastic production is employed given by Equation 1. The intuition behind the Just and Pope stochastic production function is that it can be decomposed into a deterministic component related to mean yield level and another component related to the variability of the crop yield. As a result, the model allows to estimate the effects of an input variable such as climatic shocks and socio-economic variables on average crop yields and its variance.

$$Y_{it} = f(X_{it}, W_{it}, \beta) + u = f(X_{it}, W_{it}, \beta) + \varepsilon_{it} h(X_{it}, W_{it}, \alpha)^{0.5} \quad (1)$$

From Equation 1, Y_{it} denotes crop yield of household i at time , X_{it} is a vector of explanatory variables (land, labour, seeds, fertilizers, and time period as index of technological change), W_{it} denotes the measures of climate variability (floods, drought, pests and diseases, precipitation). The estimation of $f(X)$ provides the average impact of the explanatory variables on yield while $h(.)$ offers their effect on the variability of yields, while ε_{it} is an exogenous production shock with mean zero ($E(\varepsilon_{it})$=0) and constant variance (V=σ^2_ε) equals to one to ensure positive output variance (Isik and Devadoss 2006). According to Just and Pope (1978) and Chen and Chang (2005), the parameter estimates of the first part of the model $f(X_{it}\ \beta)$ gives the average effects of explanatory variables on average crop yields, whilst the second part $h(X_{it}\ \alpha)$ reveals the effects on the variability of crop yields.

Given that the Just-Pope production function does not impose ex ante restriction on the risk effects of inputs used in the model, the increase or decrease of variability of crop yields is determined based on the sign of the regression. That is, a positive sign on any parameter implies that a rise in that variable indicates an increase of variability of crop yields, while a negative sign on the same variable indicates a decrease of the variability of crop yields.

The Just-Pope production function can be formulated in terms of either a Cobb-Douglas, or Quadratic or a translog function (Kim and Pang 2009). Sarker et al. (2012) note that the translog functional form violates the assumption of Just and Pope (1987) model because of the multiplicative interaction between the mean and variance. However, Kebede and Andenew (2011) and Hassan et al. (2010) indicate that the Cobb-Douglas production function is the best functional form in analysing the effect of climatic variability on the mean crop yields and variability. Following Kim and Pang (2009), the researcher employ the Cobb-Douglas production function to examine the impact of weather variability on mean crop yields given by:

$$Y_{it} = \delta + \beta W_{it} + \phi X_{it} + \varepsilon_{it} \quad (2)$$

From Equation 2, W_{it} denotes the measures of climate variability (floods, drought, pests and diseases, precipitation), X_{it} is a set of explanatory variables as defined above and β and ϕ are the set of coefficients to be estimated. Also, technological change in form of use of fertilizers, introduction of new crop varieties and improved crop planting practices is included.

In addition, the researcher estimated the crop yield variability function modelled as a Cobb-Douglas production function to ascertain the effects of weather variation and socio-economic factors on variation of crop yields using the Just and Pope (1978, 1979) framework. The estimated variability function is given by the following specification:

$$h(x) = \alpha_0 + \delta W_{it} + \varphi X_{it} + u_{it} \quad (3)$$

From Equation 3, W_{it} denotes the measures of climate variability and X_{it} is a set of explanatory variables as defined above. The set of parameters to be estimated are δ and φ, while is an a normally distributed error term.

MLE provides consistent and more efficient estimates than the FGLS estimation in the case of small samples (Saha et al. 1997). Because this sample size is not big enough with only three waves, this study has used the MLE techniques (Saha et al. 1997; Isik and Devadoss 2006). Along with the assumption of $Y_{it} \sim N[(f(X_{it}\ W_{it}\ \beta), h\ (Y_{it}, W_{it}, \alpha)$ and $E_{it} \sim N(0,1)$, the log likelihood function that is estimated is given by the following expression:

$$\ln L = -\tfrac{1}{2}[n^{*}\ln(2\pi) + \sum \ln(h(X,\ W_{it}, \alpha)) + \sum \tfrac{(Y - f(X, W_{it},\ \beta))}{h(X, \alpha)}] \tag{4}$$

From the log likelihood function (Equation 4), n is the number of observations. Thus, maximising the log likelihood function, the researcher obtained the effects of climate change on the household average crop yields β and on variability of crop output α. This study has estimated the Just and Pope production function for four major crops in Uganda in terms of maize equivalent per hectare.

Data Description

This study uses the Uganda National Panel Survey data (UNPS 2009/10-2012/13). The socio-economic module of the survey collected information on the climatic shocks experienced by households. The survey probes households on the various climatic shocks experienced (floods, pests attack and diseases, drought, hailstorm, livestock epidemic and fire accident), the length of climate shocks as well as the coping mechanism(s). The UNPS covered 3,514 households in 35 districts. The survey gathered detailed information on land ownership, plot size, number of crops, level of education, extension services, NAADS participation status, household size, marital status among others. In addition, the panel surveys collected information on quantity harvested, consumed and sold or stored and that destroyed by bad weather conditions.

Description of Explanatory Variables and Their Hypothesized Effect on Crop Yields

The output variable is defined as the total maize production equivalent per acre. The dependent variable is measured as total maize production equivalent per acre of planted areas of the selected crops (Maize, Cassava and Bananas) using the World Weight and Measures: Handbook for Statistics (FAO 1955).

In addition, the weather variables and climate socks plus households characteristics were hypothesized to influence crop yields. Different measures of climate change (floods, drought, pests and diseases) were used in this study following authors (IPCC 2007; Isik and Devadoss 2006; Holst and Grun 2010; Finger and Schmid 2007; Baubacar 2010), who note that climate change have significant effects on crop yields. Climate variations in form of drought, frequency and severity of extreme weather events such as droughts, floods negatively affect crop yields as noted by authors (Ssewanyana and Kasirye 2012; Partz et al. 1996). Also, access to extension services are used and these are hypothesized to have positive effect on crop yield and negative effect on crop variance (Valdivia et al. 2002). Credit facility in terms of cash is also important as it can help farmers to pay for extension services, which would increase crop yields (Di Falco et al. 2011). In addition, the age of household head is hypothesized to positively influence crop yields. Older and more experienced farmers are able to make production decisions and have greater contacts which allow trading opportunities to be discovered at lower cost than younger ones (Martey et al. 2012; Omitil et al. 2009).

Also, the researcher uses education level of the household head to analyse crop yields following Matsauoka (2008) and Kudi et al. (2011) indicate that the more educated household head is expected to be more efficient to understand and obtain new technologies in a shorter period of time than uneducated people. This is used as categorical variable in order to capture the effect of the different education attainment on crop yields. Previous findings indicate that education enables household heads to increase the tendency to cooperate with other people and participating in group activities such as farming training, credit access all which increase farm yields. However, other authors like Tura et al. (2010) show that in Ethiopia education has a negative effect on crop yields. He notes that households headed by literates are less likely to adopt improved farming technologies. This is attributed to the fact that relatively more educated household heads are youngsters and have minimal access to land, hence are land constrained.

Also, the researcher used land size allocated to crop production measured in acres following Martey et al. (2012) and Olwande et al. (2009). The authors note that large farm size, when well-managed, has a positive influence on crop yields and can enable farmers generate production surpluses. Furthermore, the researcher used improved agriculture inputs and technologies like fertilizers, high breed seeds, irrigation and these are hypothesized to have a positive and negative effect on mean crop yields and variance respectively (Palmer 2004; World Bank 2005; Wanyama et al. 2009). Also, farming experience and use of fertilizers have generally positive influences (Amaza et al. 2010).

RESULTS

Descriptive Evidence

Table 1 provides the descriptive summary statistics of the study variables. Overall, average output per acre is 255.13kg with minimum out of 146.63kg and maximum output of 1935kg. The average minimum temperature is 16.6°C and the average maximum temperature is 23°C, while average minimum rainfall is 440.7mm and the average maximum rainfall is 1133mm. The high divergence between the minimum and maximum rainfall and temperatures may indicate the possibility of weather variability.

The researcher observed that about 22 percent of households participate in the NAADS programs, while around 70 percent of the surveyed household have a male household head. The average age of the household head is 45 years. In terms of level of education of household head, 29 percent had no education, 46 percent had primary, 18 percent had secondary and 8 percent had post-secondary education. The average crop planted farm size is 1.19 acres. On an average, 60 percent of farmers use good quali-

Table 1: Summary statistics for the study variables

Variables	*Mean*	*Sd*	*Min*	*Max*
Total maize production equivalent	255.13	67.33	146.63	1935
Maximum rainfall (mm)	1133.00	169.20	514	1655
Average rainfall (mm)	440.70	62.85	262	626
Average Temperature (°C)	16.60	9.02	14	24
Maximum temperature (°C)	23.00	12.50	17	35
Male head	0.70	0.46	0	1
NAADS participant	0.22	0.42	0	1
Climatic Shocks:				
Other shocks	0.72	0.45	0	1
Drought	0.06	0.24	0	1
Floods	0.05	0.23	0	1
Pests and diseases	0.06	0.24	0	1
Land slides	0.06	0.24	0	1
Fire	0.05	0.22	0	1
Age of household head	45.92	15.17	16	99
Education of Household Head:				
No education	0.29	0.45	0	1
Primary	0.46	0.50	0	1
Secondary	0.18	0.38	0	1
Post-secondary	0.08	0.27	0	1
Marital Status:				
Never married	0.27	0.44	0	1
Married	0.55	0.50	0	1
Separated/divorced	0.08	0.28	0	1
Widow/widower	0.10	0.30	0	1
Use fertilizers	0.08	0.27	0	1
Practice irrigation farming	0.06	0.21	0	1
Use of pesticides	0.05	0.14	0	1
Use of high yielding seeds	0.22	0.34	0	1
Planted area (acres)	1.29	0.96	0.01	45
Land Tenure System:				
Lease hold	0.42	0.49	0	1
Free hold	0.02	0.13	0	1
Mailo land	0.04	0.21	0	1
Customary	0.52	0.50	0	1
Soil Quality:				
Poor quality	0.06	0.24	0	1
Good quality	0.60	0.49	0	1
Fair	0.34	0.47	0	1

Sources: Authors' tabulation from UNPS 2013 ty soils, 8 percent of households use fertilizers, 5 percent use pesticides and only 5 percent practice irrigation. In addition, on average 22 percent of households use high yield seeds. while 6 percent and 64 percent use poor and fair quality soils respectively. Regarding land tenure system, on average, only 2 percent of households own land under freehold, 42 percent under leased land, 4 percent is under mailo land while 52 percent is customary tenure. By marital status of household head, 27 percent are never married, 55 percent are married, 8 percent are separated/divorced and 10 percent are widow/widower. The data reveals that drought is the longest shock experienced by farmers for about 3.5 months, households experienced 3 months of flooding and is likely to affect crop yields.

Table 2 shows used adaptation measures used by households such as savings, labour supply, use of appropriate technologies, reduced consumption, changing crop varieties, water harvest, tree planting among others taken by households in order to mitigate the negative consequences of weather variability. Table 2 shows that households use reduced consumption more as an adaption strategy during drought by skipping meals, followed by use of savings and then labour supply. In case of livestock epidemics, household coped mainly through savings in 2009/10. In the event of crop pest in 2010/11, 39 percent of households coped by using pesticides to spray the pests. Also, in the case of drought and animal epidemics, 32 percent of the households coped through reduced consumptions, followed by savings. In 2011/12, during floods, households coped by using savings. In the case of animal epidemics, households coped mainly through saving.

Analysis of the Determinants of Average Crop Yield Results

To examine the effects of climate variation and socio-economic variables on the average maize production equivalent, a stochastic production function (Just and Pope 1978, 1979) is estimated using the MLE. Table 3 presents the results of the impact of climatic variability on average maize production equivalent at national level, while Table 4 presents the results by gender. The model is estimated based on 1381 female-headed households and 2402 male-headed households. Results in Table 4 show that a unit increase in average rainfall and average tem-

Table 2: Coping strategies by covariate shock and area of residence (% of total)

Copping strategy	*Drought*			*Floods*			*Pests*			*Livestock epidemics*		
	Rural	*Urban*	*All*	*Rural*	*Urban*	*All*	*Rural*	*Urban*	*All*	*Rural*	*Urban*	*All*
2009/10												
Borrowing	1.7	0.1	1.8	0.0	0.0	0.0	1.8	2.7	4.5	0.0	0.0	0.0
Labour supply	18.1	2.0	20.0	25.4	0.0	25.4	7.9	1.9	9.8	9.9	0.0	9.9
Technology	4.9	0.3	5.2	5.4	0.0	5.4	20.4	0.8	21.2	6.7	0.0	6.7
Savings	23.4	2.0	25.4	18.0	0.0	18.0	22.7	4.2	26.9	67.8	6.3	74.1
Reduce consumption	45.5	2.0	47.5	44.8	6.3	51.1	30.7	6.8	37.6	4.4	5.0	9.4
2010/11												
Borrowing	8.7	0.1	3.8	5.6	0.4	6	1.1	0	1.1	8.7	0.1	3.8
Labour supply	15.9	1.8	24.7	22.6	0.9	23.5	18.6	0.8	19.4	15.9	1.8	24.7
Technology	6.4	0.3	4.4	7.9	0.6	8.4	39.3	1	40.3	6.4	0.3	4.4
Savings	28.5	2.8	38.6	36	2.5	38.5	16.5	4.5	21	28.5	2.8	38.6
Reduce consumption	33.2	2.3	28.5	22.7	0.8	23.5	16.9	1.4	18.2	33.2	2.3	28.5
2011/12												
Borrowing	3.7	1.1	4.8	4.6	1.4	6.0	1.7	1.0	2.8	1.8	0.3	2.1
Labour supply	22.7	1.0	23.7	20.6	2.9	23.5	15.8	0.8	16.4	31.5	2.1	33.6
Technology	4.3	0.1	4.4	7.9	0.6	8.4	30.9	1.0	31.9	10.2	4.1	14.3
Savings	33.5	5.1	38.6	35.0	3.5	38.5	16.2	4.5	20.7	43.7	2.7	46.4
Reduce consumption	23.2	5.3	28.5	22.5	1.0	23.5	26.8	1.4	28.2	2.7	0.8	4.5

Source: Authors' tabulation from UNPS 2013 perature will increase average maize production equivalent by 11 and 4 percentage points respectively while a unit increase in maximum temperature would reduce average maize production equivalent by 12 percentage points. With a chi-square that is statistically significant at the conventional levels, the model results can be used to make valid conclusion and draw reasonable inferences.

Also, Table 3 results show that being male increases mean yields by 13 and 9 percentage points than being female. In addition, the results show that participating in NAADS have a positive and statistically significant impact on the average crop yields in all models. The results show that being a NAADS participant increases mean yields of maize equivalent between 24 and 16 percentage points than being a non-NAADS participating farmers. Also, the estimated results show that drought, floods and pests and diseases have a significant negative impact on mean yields of maize equivalent. The results show that the occurrence of drought, floods and pests and diseases reduces mean yields by 21, 18 and 8 percentage points respectively than those who did not experience these shocks.

Furthermore, the results show that household head having primary education increases average yields between 3 and 6 percentage points, while having secondary education increases mean yields between 12 and 16 percentage points among households headed with secondary education than in households headed by people with no education. The positive im-

Table 3: Determinants of mean crop yields in Uganda

Variables	*Model 1*		*Model 2*	
	Coef	*p-values*	*Coef*	*p-values*
Maximum rainfall (mm)	-0.006	(0.576)		
Average rainfall (mm)	0.113**	(0.030)		
Average Temperature	0.043***	(0.003)		
Maximum Temperature	-0.121***	(0.008)		
Male household head (Yes=1, No=0)	0.131*	(0.063)	0.093**	(0.017)
NAADS participant (Yes=1, No=0)	0.244**	(0.022)	0.157*	(0.054)
Climatic Shocks (RC: Other Shocks)				
Drought			-0.211**	(0.014)
Floods			-0.181*	(0.064)
Pests and diseases			0.078	(0.641)
Slides and erosion			0.081	(0.065)
Fire			-0.800	(0.348)
Education (RC: No Education)				
Primary	0.029***	(0.000)	0.058***	(0.001)
Secondary	0.121***	(0.000)	0.163**	(0.033)
Post-secondary	0.418	(0.562)	0.430	(0.241)
Land Tenure System (RC: Leasehold)				
Freehold	0.061***	(0.000)	0.093**	(0.008)
Mail land	0.447	(0.679)	-0.241	(0.6614)
Customary	0.008*	(0.093)	0.043*	(0.093)
Age of household head		-0.037**	(0.035)	
Age of household head squared		0.161**	(0.037	
Marital Status (RC: Never Married)				
Married	0.111*	(0.026)	0.172***	(0.000)
Separated/divorced	0.364	(0.378)	0.163	(0.120)
Widowed/widow	0.188	(0.464)	0.098	(0.375)
Planted crop area	0.221**	(0.012)	0.184*	(0.065)
Soil Quality (RC: Poor)				
Good quality (Yes=1, No=0)	0.114*	(0.091)	0.192*	(0.053)
Fair quality (Yes=1, No=0)	-0.045	(0.938)	-0.898	(0.390)
Uses organic fertilizers(Yes=1, No=0)	0.166**	(0.035)		
Use high breed seeds(Yes=1, No=0)	0.143***	(0.000)		
Use pesticides(Yes=1, No=0)	0.041	(0.882)		
Practice irrigation(Yes=1, No=0)	0.242***	(0.000)		
Constant	14.594**	(0.015)	9.575*	(0.062)
Observations	4381		4023	
Log likelihood	-143.55		-81.04	
Log χ^2	48.32	(0.000)	56.87	(0.000)

P-values in parentheses ***p<0.01, **p<0.05, *p<0.1

pact of education on average yields is in line with government's Universal Primary and Secondary Education policies that have been implemented in the country over the past ten years. Also, results show that free hold land ownership and customary land ownership increase mean yield between 6 and 9 percentage points and between 1 and 4 percentage points respectively.

As expected, the linear effect of age shows that one additional year the age of the household head reduces the mean yields by 4 percentage points, while results for age squared reveal that one additional year in the age of the household head increases the mean yields by 16 percentage points. Also, the results show that being married increases crop yields between 11 and 17 percentage points compared to household headed who are never married. In addition, a one unit increase in crop planted land size increases the mean yields between 18 and 22 percentage points, which means that to boost farm yields there is need to improve land management to ensure access to cultivatable land by farmers. Also, the results reveal that using good fertile land has a significant positive effect on crop yields and increases average crop yields between 11 and 19 percentage points in models 1 and 2. Also, the results show that using high breed seeds, fertilizers and practicing irrigation farming have a significant positive impact on average crop yields. That is, using high breed seeds, fertilizers and practicing irrigation farming increases crop yields by 17, 14 and 24 percentage points respectively.

Separate estimation of male and female headed households models (Table 4) is justified only

Table 4: Determinants of mean crop yields (maize equivalent per acre) by gender

Variables	*Female Model 1*	*Male Model 1*	*Female Model 2*	*Male Model 2*
Maximum rainfall (mm)	-0.021*** (0.009)	0.009 (0.470)		
Average rainfall (mm)	0.047*** (0.008)	0.022* (0.293)		
Average temperature	0.032** (0.004)	0.053*** (0.002)		
Maximum temperature	0.044 (0.673)	-0.028** *(0.008)		
NAADS participation (Yes=1, No=0)	0.082*** (0.005)	0.114** (0.032)	0.131* (0.086)	0.172* (0.079)
Shocks (RC: No Shock)				
Drought			-0.142* (0.050)	-0.108** (0.022)
Flood			-0.047** (0.030)	-0.027** (0.045)
Pests and diseases spell			-0.314 (0.512)	0.622 (0.568)
Landslides			-0.273 (0.592)	0.695 (0.530)
Age of head of household	0.057 (0.213)	0.038 (0.711)	0.073** (0.025)	0.102* (0.065)
Age of head of HH squared	-0.032* (0.075)	-0.013** (0.034)	-0.052* (0.092)	-0.027* (0.065)
Education (RC: No Education)				
Primary	0.051* (0.072)	0.067*** (0.000)	0.079** (0.020)	0.091***(0.000)
Secondary education	0.146*** (0.000)	0.187*** (0.000)	0.090** (0.023)	0.118***(0.007)
Postsecondary education	0.048 (0.158)	0.033 (0.180)	0.074 (0.397)	0.116 (0.351)
Marital Status (RC: Never Married)				
Married	0.094** (0.049)	0.063* (0.052)	0.132***(0.001)	0.114***(0.000)
Divorced/separated	-0.476 (0.135)	0.334 (0.485)	0.134 (0.123)	0.433 (0.111)
Widow/widower	-0.019 (0.943)	-0.045 (0.765)	-0.115 (0.323)	-0.081 (0.812)
Land Tenure System (RC: Freehold):				
Leasehold	0.043* (0.094)	0.111* (0.053)	0.088 (0.563)	0.047 (0.642)
Mailo land	0.082*** (0.000)	0.031* (0.063)	0.123 * (0.074)	0.154* (0.090)
Customary	0.075*** (0.001)	0.094*** (0.000)	0.134* (0.057)	0.143* (0.072)
Size of planted land area (acres)	0.074*** (0.000)	0.027** (0.022)	0.118***(0.001)	0.123** (0.021)
Soil Quality:				
Good quality (Yes=1, No=0)	0.011*** (0.000)	0.062** (0.028)	0.082** (0.042)	0.144* (0.099)
Fair quality (Yes=1, No=0)	0.041 (0.141)	0.023 (0.376)	0.012 (0.822)	0.014 (0.119)
Use fertilizers (Yes=1, No=0)	0.112*** (0.000)	0.141*** (0.000)	0.084***(0.000)	0.091***(0.000)
Use pesticides (Yes=1, No=0)	-0.030 (0.054)	0.558 (0.197)	-0.030 (0.054)	0.608 (0.097)
Use high yielding seeds (Yes=1, No=0)	0.114*** (0.000)	0.104* (0.013)	0.150* (0.074)	0.177* (0.053)
Use irrigation (Yes=1, No=0)	0.141* (0.054)	0.172* (0.066)	0.191***(0.000)	0.094** (0.007)
Constant	14.304** (0.033)	9.558 (0.489)	14.305 (0.849)	9.891** (0.033)
Observations	1,381	2,402	1,381	2,402
Log likelihood	-313.5	-96.75	-101.4	-464.1
Log	12.24 (0.001)	15.63 (0.000)	37.88 (0.000)	-66.68 (0.000)

P-values in parentheses ***p<0.01, **p<0.05, * p<0.1

under the condition that the regression coefficients and variances are different for the two groups of households. The poolability test about the heterogeneity of the male and female headed households is carried out to check whether it is necessary to estimate separate male and female models. In this test, the F-test is performed based on the null hypothesis that crop yields for male and female headed households is the same for the two kinds of households. However, an F-statistics of 18.12, with a probability of 0.000 derived requires that the null hypothesis is rejected at 1 percent significance level and justifying to estimate separate male and female-headed households' regressions.

First, in Table 4 average rainfall has a significant positive impact on the average crops yields while maximum rainfall has a significant negative impact on average crops yields. The results show that a unit increase in average rainfall increases mean crops yields by 5 and 2 percentage points, while a unit increase in average temperature increases crops yields by 3 and 5 percentage points for female and male-headed households respectively. Also, the results show that a unit increase in maximum rainfall reduces average crops yields by 2 percentage points for female-headed households, while a one unit increase in maximum temperature reduces average crop yields by 3 percentage points in the male-headed households. Also, households' participation in NAADS programs increases average crop yields between 8 and 13 percentage points and between 10 and 17 percentage points than non-participating farmers for female and male-headed households respectively.

Columns 2 and 3 of Table 4 show that drought and floods occurrence have a negative and significant impact on average crops yields in both models. The results show that drought occurrence reduces mean crops yields between 14 and 11 percentage points, while floods occurrence reduces mean crop yields by 5 and 3 percentage points among female and male-headed households respectively. Also, columns 3 an 4 of Table 4 show that one additional year in the age of household head increases mean crops yields by 7 and 10 percentage points for the female and male-headed households, while the effect of age squared shows that after a certain age, one additional year reduces mean crops yields between 3 and 5 percentage points for male-headed households and between 1 and 3 percentage points for female headed households.

Table 4 shows that household heads having primary education increases mean crops yields between 5 and 8 and between 7 and 9 percentage points for female and male headed households respectively. In addition, secondary education increases crops yields between 9 and 15 and 11 and 19 percentage points for female and male headed households respectively. Also, being married by household head increases average crops yields between 9 and 13 and between 6 and 11 percentage points for female and male headed households respectively. In addition, owning land under the lease hold increases mean crops yields by 4 and 11 percentage points for female and male headed household respectively, while mailo land increases mean crop yields between 8 and 12 and between 3 and 15 percentage points for female and male headed households respectively. Customary tenure system increases mean crops yield by 8 and 13 and by 9 and 14 percentage points for female and male headed households respectively. Also, the results show that a unit increase in the crop planted land size increases mean crops yields between 7 and 12 and between 3 and 16 percentage points for female and male headed households respectively. Also, using good fertile soils increases mean crops yields between 1 and 8 percentage points for female-headed households and between 6 and 14 percentage points for male-headed households.

As expected, Table 4 results show that using high breed seeds, fertilizers and practicing irrigation farming have a positive significant effect on average crops yields. Using high breed seeds increases mean crops yields between 10 and 15 percentage points, fertilizers and practicing irrigation farming increase mean crops yields between 8 and 13 percentage points and between 14 and 19 percentage respectively among female headed households. In the case of male headed households, using high breed seeds increases mean crops yields between 10 and 16 percentage, use fertilizers between 12 and 17 points and practicing irrigation farming between 9 and 17 percentage points.

Analysis of Determinants of Crop Yield Variability

Table 5 presents results for the impact of weather variability on crop yields variability at national level, while Table 6 presents the results

Table 5: Estimated determinants of crop yields variability in Uganda

Variables	*Model 1*		*Model 2*	
	Coef	*p-values*	*Coef*	*p-values*
Maximum rainfall (mm)	-0.004	(0.576)		
Average rainfall (mm)	-0.032**	(0.004)		
Average Temperature	-0.072***	(0.000)		
Maximum Temperature	0.047***	(0.001)		
Male household head (Yes=1, No=0)	-0.083*	(0.063)	-0.041**	(0.007)
NAADS participant (Yes=1, No=0)	-0.131*	(0.006)	-0.062**	(0.004)
Climatic Shocks (RC: No Shocks)				
Drought			0.071**	(0.014)
Floods			0.043*	(0.064)
Pests and diseases			0.021	(0.541)
Slides and erosion			0.051	(0.365)
Fire			-0.037	(0.348)
Education (RC: No Education)				
Primary	-0.031***	(0.000)	-0.081***	(0.001)
Secondary	-0.019***	(0.000)	-0.097**	(0.023)
Post-secondary	0.048	(0.143)	0.066	(0.428)
Land Tenure System (RC: Leasehold)				
Freehold	-0.145	(0.787)	-0.014	(0.638)
Mailo land	-0.141	(0.359)	-0.061*	(0.064)
Customary	-0.024**	(0.042)	-0.015*	(0.083)
Age of household head	-0.041**	(0.024)	0.001	(0.481)
Age of household head	0.024**	(0.014)	-0.018*	(0.069)
Marital Status (RC: Never Married)				
Married	-0.041*	(0.056)	-0.093***	(0.000)
Separated/divorced	0.063	(0.258)	0.170	(0.374)
Widowed/widow	0.085	(0.477)	-0.143	(0.871)
Planted crop area	-0.141***	(0.000)	-0.091**	(0.004)
Soil Quality (RC: Poor)				
Good	-0.047*	(0.0091)	-0.052***	(0.000)
Fair	-0.029	(0.438)	-0.044	(0.357)
Uses organic fertilizers (Yes=1, No=0)	-0.069***	(0.000)		
Use high breed seeds (Yes=1, No=0)	-0.091***	(0.000)		
Use pesticides (Yes=1, No=0)	0.041	(0.282)		
Practice irrigation (Yes=1, No=0)	-0.118**	(0.003)		
Constant	9.907	(0.427)	0.205	(0.297)
Observations	4.380		4.023	
Log likelihood	-481.3		-160.6	
Log	18.32	(0.000)	81.87	(0.000)

P-values in parentheses *** p<0.01, ** p<0.05, * p<0.1

by gender. Model 1 results in Table 5 show that average rainfall and temperature have a negative and significant impact on crops yields variability while maximum temperature has a positive and significant impact on crops yields variability. The results show that a unit increase in average rainfall reduces crop variability by 3 percentage points, while a unit increase in average temperatures reduces crops yields variability by 7 percentage points and maximum temperature increases crops yields variability by 5 percentage points. Also, the results show that male headed households are likely to experience low yield variability between 4 and 8 percentage points, while participation in NAADS programs reduces crop yields variability between 6 and 13 percentage points.

Model 2 in Table 5 shows that occurrence of drought increases crop yields variability by 7 percentage points while occurrence of floods increases crop yield variability by 4 percentage points. Also results show that having primary education and secondary education by household head reduce crops yields variability between 3 and 8 and between 2 and 10 percentage points respectively. As expected, results show that owning land under mailo land and customary land reduces crops yields variability by 6 and 2 percentage points respectively. Also, results show that a one additional year in the age of the household head reduces the crops yields variability by 4 percentage points, while for age squared, one additional year increases crops yields variability by 2 percentage points. Also, being married by the household head reduces crops yield variability between 4 and 9 percentage points. In addition, a unit increase in planted area by one acre reduces crop yield variability between 9 and 14 percentage points. In addition, the results show that using good fertile soils reduces crop yield variability by 5 percentage points than those using poor soils. Furthermore, use of fertilizers, high breed seed and irrigation significantly reduces crops yield variability by 7, 9 and 12 percentage points respectively.

Table 6 presents results for the impact of weather variability on crop yields variability by gender as justified by the poolability tests. First, the results show that a unit increase in average rainfall reduces crop yields variability for female and male farmers by 3 and 6 percentage points respectively. Also, the results show that a unit increase in maximum rainfall increases crop yields variability for female farmers by 6 percentage points, while a unit increase in maximum temperature increases crops yields variability by 5 percentage points for male farmers. In addition, the results show that participation in NAADS pro-

Table 6: Impacts of weather variability on crop yields variability by gender

Variables	*Model 1*		*Model 2*	
	Female	*Male*	*Female*	*Male*
Maximum rainfall (mm)	0.061*** (0.001)	0.071 (0.470)		
Average rainfall (mm)	-0.034*** (0.008)	-0.056** (0.005)		
Average Temperature	-0.015 (0.483)	-0.048***(0.002)		
Maximum Temperature	0.023 (0.883)	0.053***(0.008)		
NAADS participation (Yes=1, No=0)	-0.052*** (0.001)	0.184** (0.032)	-0.072** (0.008)	-0.132** (0.009)
Climatic Shocks:				
Drought length (Yes=1, No=0)			0.041* (0.050)	0.033* (0.061)
Flood length (Yes=1, No=0)			0.022** (0.030)	0.047* (0.069)
Pests and diseases spell (Yes=1, No=0)			0.081 (0.512)	0.033 (0.568)
Landslides (Yes=1, No=0)			-0.035 (0.592)	0.041 (0.530)
Fire (Yes=1, No=0)			0.011 (0.955)	0.065 (0.303)
Education (RC: No Education)				
Primary	-0.101* (0.009)	-0.071***(0.000)	-0.017 (0.920)	-0.201 (0.521)
Secondary education	-0.051*** (0.000)	-0.111***(0.000)	-0.044** (0.023)	-0.105*** (0.007)
Postsecondary education	-0.048 (0.412)	-0.281 (0.140)	-0.093 (0.497)	-0.017 (0.331)
Land Tenure System (RC: Leasehold)				
Free hold	-0.015* (0.094)	-0.052* (0.019)	-0.057*** (0.000)	-0.081** (0.042)
Mail land	-0.042*** (0.000)	-0.061* (0.063)	-0.073* (0.014)	-0.075 (0.390)
Customary	-0.084 (0.120)	-0.041 (0.116)	-0.024* (0.010)	-0.088*** (0.000)
Age of household head	0.357 (0.714)	0.064 (0.165)	0.005 (0.213)	-0.003 (0.711)
Age squared of household head	-0.136*** (0.000)	-0.012* (0.079)	-0.073* (0.009)	-0.032*** (0.000)
Marital Status (RC: Never Married)				
Married	-0.062** (0.049)	-0.111***(0.000)	-0.018***(0.000)	-0.046*** (0.000)
Divorced/separated	-0.543 (0.135)	0.063 (0.415)	-0.023 (0.143)	-0.063 (0.433)
Widow/widower	-0.045 (0.194)	-0.256 (0.765)	-0.234 (0.253)	-0.222 (0.892)
Size of planted crop area	-0.131* (0.009)	-0.174** (0.004)	-0.051***(0.000)	-0.112** (0.041)
Soil Quality (RC: Poor)				
Good	-0.084*** (0.000)	-0.113* (0.005)	-0.014 (0.046)	-0.129** (0.009)
Fair	0.1114 (0.119)	-0.027 (0.476)	0.042 (0.147)	0.033 (0.529)
Uses organic fertilizers (Yes=1, No=0)	-0.082*** (0.000)	-0.118* (0.036)		
Use high breed seeds (Yes=1, No=0)	-0.011** (0.049)	-0.123** (0.032)		
Use pesticides (Yes=1, No=0)	-0.533 (0.135)	0.363 (0.485)		
Practice irrigation (Yes=1, No=0)	-0.124*** (0.000)	-0.152**(0.025)		
Constant	13.268*** (0.001)	14.442* (0.051)	8.137* (0.085)	10.311** (0.031)
Observations	1,381	2,402	1,381	2,402
Log likelihood	-939.1	-360.5	108	-136.5
Log	5.241 (0.002)	15.63 (0.000)	37.88 (0.000)	66.68(0.000)

P-values in parentheses *** p<0.01, **p<0.05, **p<0.1

grams reduces crop variability between 5 and 7 percentage points for female-headed households and between 8 and 13 percentage points for male headed households than their non-participating counterparts.

In addition, Table 6 columns 3 and 4 show that drought occurrence increases crops yields variability by 4 percentage points among female headed households and by 3 percentage points among male-headed households who experienced drought than those who did not. Also, flood occurrence increases crops yields variability by 2 percentage point among female headed households and by 5 percentage point among male-headed households who experienced floods than those who did not. Furthermore, having primary education by the household head reduces crops yields variability by 10 and 7 percentage points in the female and male-headed households respectively, while having secondary education by household heads reduces yield variability by 5 and 11 percentage points among female and male-headed households respectively.

Furthermore, owning land under freehold reduces yields variability between 2 and 6 percentage points, mailo land between 4 and 7 percentage points among female-headed households. In the case of male headed households, owning land under free hold reduces crop yield variability between 5 and 8 percentage points, mailo land by 6 percentage points, and customary land ownership between 2 and 9 percentage points than leasehold among male-headed households. Also, one additional year in the age of the household head reduces crops yield variability between 3 and 7 percentage points and between 1 and 3 percentage points for female and male-headed households respectively. In addition, being a married household head reduces crops yields variability between 2 and 6 percentage points for female-headed households and between 5 and 11 percentage for male-headed households than among the never married.

Also, the size of the crop planted land area are negative and statistically significant. This result indicates that a unit increase in acreage of cultivated land will reduce crop yields variability between 5 and 13 percentage points among female-headed households and between 11 and 17 percentage points among male headed households. Also, using good fertile compared to poor soils reduces crops yield variability by 8 percentage points and 11 and 13 percentage points for female and male-headed households respectively. Also, the results show that use of fertilizers, high breed seed and irrigation increase mean crop yields between 8 and 12, 1 and 12, and 12 and 15 percentage points for female and male headed households, respectively.

DISCUSSION

In Table 3 the researcher observed that average rainfall and average temperature significantly affect average crop yields and variability among farmers. The results show that a unit increase in average rainfall increases crop yield by 11 and 4 percentage points respectively while a unit increase in maximum temperature would reduce average maize production equivalent by 12 percentage points. This finding is in line with that of Schlenker and Lobell (2010) and Rowhani et al. (2010) who found that weather variability in terms of temperatures and precipitation affect crop yields. Also, the finding is similar to findings of other authors (IPCC 2007; Gregory et al. 2005; Climate Change 2007; Wang et al. 2009), who note that weather vulnerability on agricultural productivity. Also, the author conclude that long and more frequent drought spells, heavier and erratic rains affect ecosystem and overall crop production. This finding implies that the need for government and other stakeholders to undertake measures of climate adaptation measures such as modern farming methods, and use of irrigation among others.

As expected, when the researcher disaggregated women-run households, they found that male-headed household crop yields were higher than their female counterparts, the male-female crop yields gap is 13 percent and variability is 8 percent in Table 3. This finding is in line with previous authors (Martey et al. 2012; Olwonde et al. 2009), who noted that planted farm size as well as farm management increase crop yields. This could be attributed to the fact that male-headed households have more access to farm inputs and have more land than their female counterparts. The results are, indeed, rather interesting, with the most notable difference being that male-headed households enjoy a bigger advantage in both mean crop yields and variability than female-headed households. Also, the crop yields gap difference between male-headed households and female-headed households due to education level of household head is between 2 and 6 percent. This suggests that male-headed households experience an even greater advantage over female-headed households even if they have the same level of education training other thing remaining constant.

Also, the researcher found that being married compared to single has a strong effect on mean crop yields that leads to a marital female crop yield gap of 2 percentage points. This finding means that being married by the household head is an important factor that affect crop yields variability among households. This finding is similar to Matsauka (2008) and Kude et al. (2011), who found the educated households head to be efficient and significantly increase crop yields.

As expected, the researcher found that using high breed seeds, fertilizers and practicing irrigation farming have a significant positive impact on average crop yields. This finding is similar to Palmer (2004), Wanyama et al. (2009) and Amanze et al. (2010) who found use of improved inputs and technology such as fertilizers, high breed seeds and irrigation significantly increase crop yields. The implication of this finding is that in order to boost crop yields, more attention should be focused on the ease by which farmers can get access to high breed seeds, organic fertilizers and also the means of adopting irrigation farming. However, speculatively, given that most farmers are poor and cannot afford farming inputs, these efforts can easily be realised by rehabilitating the farmer's cooperative societies that are likely to be effective in more outreach program to all farmers.

Weather variability in form of occurrence of drought, floods and pests and diseases reduce mean yields by 21, 18 and 8 percentage points respectively. This finding is similar to results by Partz et al. (1996) and Baubacar (2010), who concluded that climate variability affect farm production. This finding is in line with findings by Hisali and Kasirye (2008) who note that 30 percent of crop damage in Uganda is attributed to adverse climatic factors. This finding is consistent with the current assertion in the literature that weather variability is more likely to affect female-headed households than male-headed households. In this study, the researcher found this to be true amongst female-headed households. Speculatively, and as suggested by the reviewed literature, the intensity and length of weather variability are likely to have profound effect of households' crop yields irrespective of the gender of household head. This means that basically drought creates unfavourable weather conditions for good crop growth while floods may lead to rotting of crops like cassava tubers, and hence have a significant impact on crop yield variability.

Somewhat puzzling is the finding that older household heads enjoy even more of an advantage, as shown by an increase in the crop mean yields gap with an increase in age after a certain age. This finding is similar to Martey et al. (2012) and Omitil et al. (2009), who found that older and more experienced farmers are able to make decisions and have greater contribution and significantly increase crop yields than young ones.

More specifically, here the researcher showed the contribution of each household characteristics to the explained and unexplained part of crop yield gap. Overall, the researcher observed that education of the head of household and participating in the NAADS programs significantly affect the mean crop yields of households. This finding is similar to Di Falco et al. (2011), who found that use of extension services significantly increase crop yields. It is observed that primary education increases average yields between 3 and 6 percentage points, while having secondary education increases mean yields between 12 and 16 percentage points among households headed by secondary education than in households headed by people with no education. The positive impact of education on average crop yields is in line with government's Universal Primary and Secondary Education policies that have been implemented in the country over the past ten years. This suggests that normalising these factors will increase mean crop yields and reduce crop yield variability among households. The finding is in support of government universal primary and secondary education aimed at ensuring that every Ugandan acquires reasonable education.

The researcher found that free hold land ownership and customary land ownership increase mean yield between 6 and 9 percentage points and between 1 and 4 percentage points respectively. This finding is similar to Matsauka (2008) and Kude et al. (2011), who found the educated households head to be efficient and significantly increase crop yields. The results are consistent regarding the nature of potential investments under the different land ownership in the country. This is because when people are young they are less focused as they have no family responsibilities and when people get old they have heavy family responsibilities and hence are more focused in making farming decisions which increase crop yields. This implies that the nature of land ownership is an important driver of agriculture investments and government should put in place measures to address land ownership problem.

Results indicate that a one unit increase in planted land size will increase the mean yields between 18 and 22 percentage points, which means that to boost farm yields there is need to improve land management to ensure access to cultivatable land by farmers. This finding is similar to Martey et al. (2012) and Olwonde et al. (2009), note that farm size for planted crops significantly increases crop yields. Being married has a strong positive impact on crop yields. This finding means that married household heads work hard to ensure that their families enjoy a good welfare.

CONCLUSION

The study sets out to examine the impact of weather variability on crop yields among households taking into account the gender perspective. The study uses the Uganda National Panel Survey data (2013) and employs panel estimation strategy. A household's experience of weather-related crop failure has the largest coefficient in this case and statistically significant, suggesting that this is the main contributor, followed by a household's size of cultivated land, education and age of household head. The positive sign on mean crop yields, education and land fertility suggest that these factors have an effect mainly in male-headed households. The negative coefficient on household size, on the other hand, suggest that they may play a larger role in female-headed households. Interestingly, the researcher observed that when they included climatic shocks (drought, pests and diseases and floods), the mean crop yield gap increased somewhat.

Overall, this study exposes interesting results and allows us to draw five conclusions. First, the researcher observed a statistically significant gender crop yields gap of 4.1 percentage points between male and female-headed households, and this gap is even larger (21.9%) when separate models are estimated. That is, female headed households have lower crop yields and are more unproductive. Second, households' participation in NAADS programs and the level of education have large contributory effects on crop yields among farmers. Third, the researcher found that participating modern farming use (for example, use of fertilizers, herbicides, irrigation and mulching) boosts the households' mean crop yields and reduces the crop yields variance. Fourth, participating in these activities reduces the crop variability gap to 10 percentage points amongst female headed-households but increases the gap by 27.4 percentage points among the male headed households. This suggests that, although modern farming techniques are beneficial to all households, male-headed households receive more crop yield advantage by participating in these activities than female-headed households.

Fifth, the crop yields gap due to different land tenure systems is clear among male-headed households and female-headed households. Crop yield gap is quite significant between male-headed households who own lad under mail land compared to their female counterparts. Sixth, weather related crop failure also contributes to the crop yield gap. The researcher observed that weather-related crop failure due to drought, pests and diseases and floods affect mean crop yields in almost equal proportions, but less so for the male-headed households. This suggests that, because male-headed households have more access to land, they are likely to have more cultivated and planted land areas in comparison to female-headed households if adaptive strategies are not adopted.

RECOMMENDATIONS

From a policy design perspective, the results suggest that policies will be more beneficial, in light of the future prospects of climate and weather variability, if they take a gender response approach. First, the results show that average rainfall and average temperature significantly affect mean crops yields, while maximum temperatures and rainfall, drought and floods significantly reduce mean crops yields and increase crops variance. This implies that, government and other stakeholders should devise means of educating farmers on water preservation measures and adopting drought resistant crops that can survive during long dry spells. Also, there is need to equip the country's Metrology Department in order to produce accurate and reliable weather forecasts in order to guide farmers on the start of the planting seasons to avoid being affected by drought and floods.

Second, the results show that households' participation in the NAADS programs positively influences mean crops yields and reduces variability of crops yields. This finding implies that through the NAADS government should increase empowerment to farmers through training, facilitation, and networking to acquire modern farming techniques across the country. This in addition to on-farm development of technical innovations will ensure relevance and assistance that can help to overcome the critical production bottlenecks that undermine household agricultural practices. In addition, in order to address gender based inequalities, the extension agents should include household heads and their spouse in all their training activities.

Also, government through NAADS should initiate extension services targeted specifically to women farmers. This will require to hire female field agents to provide improved technical skills and modern farming technology through training to small and marginal female. Also, to strengthen extension services provision, government should increase hiring and field deployment of female staff for better mobilisation of households especially women's groups and training of women leaders at the group and village levels. Basically, the hired female staff should be active, practising farmers and willing to adopt extension recommendations on at least part of their land and use them as demonstration farms where other farmers can learn new farming practices.

Also, the results demonstrate that improvement of farmer's access to and use of farm inputs and practicing irrigation significantly increase mean crops yields and reduce the crop yield variability. Therefore, there is need for policy makers and administrators to provide basic farm inputs to farmers because access to farm inputs play an important role in enhancing households' farm productivity. In addition, given the importance of education in enhancing increased crops yields, there is need for government in its agricultural extension strategies to establish training centres with separate washing and sleeping accommodations for men and women and do provide facilities for the care of babies to promote women's.

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