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(Research Article)

Effects of floods on smallholder crop production in Eastern Uganda

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Abstract

Smallholder farmers encounter crop losses consequent to floods in eastern Uganda. It is envisaged that with increasing climate variability, flooding effects on smallholder crop production will increase. Yet, information to guide adaptation and resilience building strategies is limited. This study used cross sectional data to determine the effects of floods on agricultural production in Bukedea and Kapelebyong Districts. Findings showed that grain and root crop losses consequent to floods approximated 35 and 60% of expected output, respectively. This significantly effects crop output and smallholder household food security. Therefore, interventions targeting reduction of output loss and drudgery consequent to floods would unravel flooding effects on crop production.

Keywords: Floods; Smallholder; Crop; Output; Loss

1. Introduction

Floods cause over 30% of economic losses world over [1]. In Sub-Saharan Africa, floods affect about 38 million people causing the death of about 13,000 lives in a period of about 33 years.[2]. The combined effect of drought and floods consequent to climate change cause annual gross domestic product (GDP) loss of 1.7% in Malawi [3]. Similarly, in Mozambique, floods caused a decline of 7% in real annual growth rate, washed away 150,000 homes, killed 700 people and generally affected livelihoods [4]. In West Africa alone, about 500,000 people per year are affected by floods [5]. For example, Benin, suffered economic loss of about 100 million United States dollars after experiencing the year 2010 floods [6]. In eastern Africa, abundant rains caused localized flooding, mudslides, flashfloods, and river overflows causing casualties, population displacement, infrastructure damage, and crop damage [7]. Developing countries' agricultural sectors absorb about 22 percent of the total damage and losses caused by natural hazards [4]. This significantly affects the livelihoods of majority of the vulnerable populace that entirely depend on agricultural production as a source of livelihoods.

Floods cause significant damage to property, infrastructure and agriculture in Uganda. Annual GDP loss of over 62 million dollars has been attrbuted to floods [8]. Heavy rainfall caused severe floods in different parts of the country resulted to significant damage and population displacement [7]. In 2007, floods destroyed crops and residential structures in rural areas, leaving several people in food crisis [9]. Floods waters have been reported to damage farmlands, uproot crops and burry them in silt [10].. Destruction of farm stores by floods greatly affects seed and food availability (Armah et al., 2010). Floods have led to increase in biotic and abiotic stressers [4]. Through soil water lodging and soil erosion, floods affect soil aeration and fertility leading to poor plant growth and yields [11].. Prevalent rains promoted breeding and development of locusts thus facilitating their outbreak across the region. Consequently, agricultural production and livelihoods especially among the rural communities register a decline.

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Apart from affecting agricultural production, floods affect the agrifood distribution through their effects on road infrastructure [12]. Floods create galleys, break bridges, bring debris garbage and water pools on roads thus interrupting traffic flow in most parts of the country. This also affects labour productivity as well as trade because workers and goods fail to reach their destinations at appropriate times. The flooding effects exacerbate the already prevailing accessibility and connectivity and labour productivity snags in rural areas.

The Uganda Agricultural Census of 2008/2009 report observed that 7% of the country's 3.95 million agricultural households were prone to flooding, with most incidences occurring in the eastern region [13]. According to the Climate Change knowledge portal, Uganda encountered 20 floods, 40 epidemic, 9 drought and 5 landslide events from 1900 – 2018, which altogether caused over 200,000 deaths and at least 80 million dollars economic loss. Floods are envisaged to increase with increase in climate change, which will yield adverse effects on food production and distribution thus affecting food availability and affordability, especially among the already vulnerable communities. This will constrain the realisation of the sustainable development goal of achieving food security and improving livelihoods, hence the need for information to guide floods adaptation planning for resilience building. This study therefore assessed the effects of floods on smallholder farming so as to inform community based floods management strategies.

2. Methodology

Various parts of Uganda have been affected by floods, with the most affected entailing Mbale, Manafwa, Bukedea, Bududa, Kumi, Soroti, Katakwi, Amuria, Lira, Pader, Kitgum, Nebbi, Gulu and various districts in Central Uganda [14].. So, the study was carried out in Eastern Uganda. Multistage sampling criteria involving both purposive and random sampling methods was employed for sample selection. The districts and parishes were purposively selected so as to obtain households that experienced floods to share their knowledge and experience. In total, two districts and four parishes participate in the study. The study parishes comprised of Amaseniko and Orungo in Amuria District and Abilaep and Kamutur in Bukedea District. In order to minimize sampling bias, random sampling technique was used to select 20 respondents per parish. The sampling process was aided by lists generated with the help of local council leaders and extension workers.

Bukedea District has a population of about 186,400 people and covers a total area of 1,049.34 km^2, of which dry land and wetlands constitute 1,035.84 km^2 and 13.5 km^2, respectively.

Henceforth, a cross-sectional survey was carried in the four parishes. Sample data were collect using pretested questionnaires and key informant interview guides. The study employed exploratory data analysis and Ordinary Least Squares (OLS) regression techniques to generate descriptive statistics and model parameter estimates used to explain the nature and magnitude of flooding and its effects on smallholder farming.

3. Results and discussion

3.1. Farmer characteristics

The study findings showed that on average, land allocated to agricultural production stood at 2.136, 1.933 and 1.906 acres in 2018, 2019 and 2020, respectively. According to the agricultural census report of 2008/2009, the average smallholder land holding in eastern region was 1.1 acres per farmer [13] suggesting that there was significant improvement in land allocation to crop production. This may also imply that farmers fully employed the available land in agricultural production, though this may be attributed to inaccuracies in land sample data that could be due to measurement errors.

Gender disaggregated findings showed that land allocation to agricultural production gradually decreased from 2.304 to 1.963 acres for women and 2.016 to 1.865 acres for men, over tthe years 2018 to 2020 (table 1). Female farmers in both districts employed more land to agricultural production compared to their male counterparts. This is contrary to earlier findings that demonstrated that female farmers had less land for agricultural production compared to their male counter parts [15]. This finding may be attributed to land policy reforms [16] which provides for equitable property ownership. Across districts, Bukedea registered a decrease in average land allocated to agricultural production from 2.328 acres in 2018 to 1.887 acres per farmer in 2020 (table 1), while in Amuria land allocation to farming approximately remained constant in 2019 and 2020. Bukedea District employed more land in agricultural production compared to Amuria District.

Table 1 Crop acreage by gender and district

Year	Female		Male		Amuria		Bukedea		Overall	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
2018	2.304	1.145	2.016	1.089	1.87	0.757	2.328	1.287	2.136	1.112
2019	2.019	1.164	1.875	0.875	1.629	0.752	2.194	1.110	1.933	0.996
2020	1.963	1.018	1.865	0.969	1.671	0.866	1.887	1.056	1.906	0.984

3.2. Effects of floods

The study findings showed that the major effects of floods include soil erosion, water-logging, damage to crops, property and infrastructure as well as human, animal and ecosystems health (table 2). Crop damage was the most devastating effect of floods in the communities under study as demonstrated by over 80% of the respondents (table 2). This was also alluded to by an earlier study that observed that floods submerged crop fields and vital infrastructure like roads, schools and houses [12]. Floods eroded soil, uprooted and buried crops in silt, while the stagnant water on farm lands resulted to crop rotting, especially on root crops. This at times resulted to total crop loss. It has also been observed that floods cause over 70% crop loss [17]. In Uganda, devastating effect of floods on smallholder farming especially in Amuria and Katakwi Districts necessitated supply of food aid [9].

Table 2 Effects of floods on smallholder farmers' livelihoods

Effect	Amuria		Bukedea		Total	
	F	%	F	%	F	%
Crop damage	35	44	31	39	66	83
Infrastructural damage (roads, bridges etc)	40	50	39	49	79	99
Property damage (residences, food stores)	0	0	7	9	7	9
Animal health hazards	14	18	31	39	45	56
Human health hazards	7	9	21	26	28	35

Over 90% of the respondents observed that flood waters damaged infrastructure such as roads and school buildings. The most affected were the roads as flood waters eroded soil, created galleys as well as damaging bridges which often times interrupted traffic flow. This apparently affected crop marketing resulting to high postharvest losses.

Floods also affected human health and livelihoods through pollution related hazards. In that regard, 35% of the farmers indicted that they experienced disease outbreaks consequent to floods. Flood waters polluted domestic water sources and the ecosystem by depositing massive amounts of waste and silt, apart from transporting toxic substances like petroleum products, agro and other chemicals to the water bodies. In some instances, floods caused loss of human lives through drowning.

3.3. Effects of floods on crop production

Findings showed that the main crops grown in the area of study include cassava, sweet potatoes, maize soybean, beans, cowpeas, sorghum, millet, groundnuts, sunflower, sesame and green gram. The average crop outputs for the years 2018, 2019 and 2020 were as presented in table 3 below. Overall female farmers realized higher average output compared to male farmers during the years 2018 and 2019. Across districts, Bukedea farmers realized higher average outputs compared to Amuria District farmers. This could be because Amuria Districts experienced worse floods than Bukedea District during the years under study.

Cassava, maize, sunflower, sorghum, groundnuts, beans/cowpeas and soybean constituted the major crops damaged by floods. Farmers' crop loss experience varied by gender and across districts. Total crop loss was incurred by 11 and 9% of women during 2018 and 2019, respectively as compared to 9 and 6% male farmers during the same period, respectively (table 4). During the year 2020 a higher proportion of male farmers (15) incurred total crop losses compared to females (12%). This could be due to the effects of the Covid 19 lockdown which made it quite difficult for male farmers to attend to their fields, especially for instances where farmlands were located farm away from homesteads. Generally, majority (24%) of female farmers experienced estimated crop loss of $<50\geq10\%$ in 2018, but the situation worsened during the years 2019 and 2020 as majority (21 and 17%) of them incurred crop losses of <100≥50% of expected output (table 4). On the other hand, majority (25, 25 and 22%) of male farmers incurred crop losses of <100≥50% in 2018, 2019 and 2020. This could imply that the female farmers innovated means of minimizing output loss consequent to floods incurred compared to the male farmers (table 4).

Table 3 Crop output by gender and district

Year	Expected output				Lost output					
	Female		Male		Amuria		Bukedea		Overall	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
2018	1691.300	961.492	1230.000	791.364	1326.090	714.716	1678.130	1136.132	1531.910	997.937
2019	1311.110	838.650	1230.000	791.364	1051.610	711.276	1444.440	846.318	1262.690	805.443
2020	1188.890	877.175	1222.970	814.844	1150.000	713.216	1279.310	1055.387	`1208.590	879.844

Table 4 Crop loss percentage by gender and district

Category	**2018**			**2019**			**2020**		
Crop loss proportion	**Female (%)**	**Male (%)**	**Total (%)**	**Female (%)**	**Male (%)**	**Total (%)**	**Female (%)**	**Male (%)**	**Total (%)**
[1]100%	11	9	20	9	6	15	12	15	28
[2]<100≥50%	5	25	30	21	25	46	17	22	38
[0]<50≥10%	24	22	46	10	27	37	12	22	34
[3]<10%	2	2	4	0	1	1	0	0	0
Total	42	58	100	40	60	100	42	58	100
	Amuria %	**Bukedea %**	**Total %**	**Amuria %**	**Bukedea %**	**Total %**	**Amuria %**	**Bukedea %**	**Total %**
[1]100%	9	11	20	9	6	15	17	11	28
[2]<100≥50%	15	16	31	21	25	46	25	14	38
[0]<50≥10%	16	29	45	15	22	37	12	22	34
[3]<10%	2	2	4	1	0	1	0	0	0
Total	42	58	100	46	54	100	54	46	100

Crop loss proportion was calculated by dividing estimated crop loss by expected output

There were no significant crop losses noted across districts as well as by gender. Overall, more than 50% of the farmers incurred crop losses of 50 - 100% of the expected output. Overall crop loss attributed to flooding amounted to at least 10% of the expected crop output in 2020, suggesting that effects of flooding on crop production are worsening. Hence, need for urgent response with regard to development and implementation of floods mitigation and resilience building strategies.

4. Model results on effects of floods on crop production

Ordinary Least Squares (OLS) model estimates using lost output as proxy for floods showed that the previous period output, current output, household size and gender of farmer significantly affected crop production. The model's goodness of fit test estimate measured by adjusted R^2 shows that the model explains 43.1% of the variation in crop acreage. Specifically, the model results showed that the previous period's lost grain crop output significantly affected production at 10% significance level (table 5). On the other hand, the current period's lost root crop output significantly affected crop production at 1% significance level (table 5). The previous periods' lost grain output leads to 34.5% acreage reduction in the subsequent production period while current period's lost root crop output leads to about 60% acreage increase in the subsequent production period. This could be because root crops are staple crops that are highly depended upon for household food security in the region. As such, a jolt in their production triggers prospective increase in production aimed to counter the shock for food security attainment. Cuñado and Ferreira (2011) [18] similarly observed that flood shocks yield positive impact on the growth rate of the gross domestic product (GDP) and that the increase in agricultural growth in the year after a flood is larger and more persistent in developing countries. This generally affects planning as it ether yields deficits/famine in severe deficit situations or surpluses that result to great post-harvest losses due to insufficient/inefficient post-harvest management.

Table 5 Ordinary Least Squares (OLS) model results of factors affecting crop output

Variable	Unstandardized Coefficient	Standard Err	Standardized Coefficients	t-value	P-value
LostRoot2020	0.001	0.000	0.599	3.406	0.003
Lostgrain2020	0.000	0.001	-0.037	-0.190	0.851
LostRoot19	-0.001	0.000	-0.309	-1.628	0.119
LostGrain19	-0.001	0.000	-0.345	-1.949	0.066
HH_size	0.216	0.080	0.508	2.685	0.014
RoadCond	0.124	0.339	0.057	0.365	0.719
SexComp	0.590	0.343	0.287	1.722	0.100
Age	-0.031	0.021	-0.271	-1.522	0.144
Constant	1.581	0.713		2.216	0.038
Probability of F	0.009				
R-Squared	0.593				
Adjusted R-squared	0.431				

Household size similarly had a positive and significant effect on production. Model results showed that a 1% increase in the number of household members leads to 53.4% increase in crop acreage (table 5). This can be attributed to the effect of household size on farm, harvest and postharvest management labour. Larger households apparently provide more labour for farm and floods management compared to smaller households. San (2018) [19] similarly observed that increase in family labour leads to increase in monsoon paddy farm income. Household size may increase labour availability for increasing production, but it may also increase dependency ratio and as such affect production negatively [20].

5. Conclusion

This study analysed the effects of flooding on smallholder crop production. Findings showed crop, infrastructural and property damage after floods affected crop production. Root and grain crop losses consequent to floods significantly affected crop production. Therefore, strategies for enhancing smallholder crop production in view of increasing climate variability could focus on minimizing crop output loss and drudgery consequent to floods.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors have not declared conflict of interest.

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