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Economic impact of drought among smallholder livestock farmers surrounding Lake Mburo National Park, Uganda

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A survey was conducted among smallholder farmers around Lake Mburo National Park, Uganda whose mean household (H/h) size was 5.4 ± 0.2 persons having 40.6 ± 0.5 and 3 ± 0.4 acres of land in Kiruhura and Isingiro districts respectively to determine the impact of drought. Farmers in Kiruhura district were livestock keepers while in Isingiro they were crop growers. In Kiruhura district, during drought periods cattle sale off-take increased 2.3 times, their crude mortality rate increased 1.73 times and prices decreased by 46.8%. For goats, sale off-take did not increase but the crude mortality rate decreased by 47.2% and sale prices increased 2.1 times. Total Gross Output from Agricultural Enterprises (TGOAE) per H/h was USD 17,782.1 and USD 1,762.4 annually in Kiruhura and Isingiro districts respectively, of which 83.8% was from cattle milk output in Kiruhura and 67.6% was from crop output in Isingiro. In Kiruhura and Isingiro the economic cost (EC) due to drought per H/h was USD 10,437.4 and USD 1024.8 respectively which was 58.7% and 58.1% of TGOAE respectively. In Kiruhura, 83.5% of EC losses were caused by milk production losses and 96% were caused by crop failures in Isingiro. The frequency and amount of milk and food consumed was drastically decreased. In conclusion, the study area suffered high losses due to drought with Isingiro experiencing total crop failure. While Kiruhura district encountered more economic losses, it was in a much better position to handle shocks brought by drought because it had diversified sources on livelihoods. From this study it became apparent that both livestock and crop farmers in areas with variable climate in Uganda suffer the brunt of climate change brought by drought. They should therefore be sensitized about urgency and the need to develop and adopt participatory mitigation and adaptive resilience measures to address impacts of drought. Exchange rate: 1 United States Dollar (USD) = 3617 Uganda Shillings (UGX).

Keywords Economic cost, Drought, Climate changes, Smallholder farmers, Lake Mburo National Park

Climate change has become a major single global environmental challenge threatening the livelihoods of humanity. It has affected the basic elements of life especially access to water, food, health and use of land¹. Climate change causes frequent intense catastrophic droughts, heat waves, melting glaciers leading to rising sea levels causing flooding of low-lying coastal areas and warming of oceans which lead to storms causing direct havoc to plant and animal life. The frequency and intensity of droughts as indicators of climate change in sub-Saharan Africa have increased¹ affecting Horn of Africa in Somalia and Ethiopia, East Africa in Uganda, Kenya, Southern Sudan and Tanzania; in West Africa in Nigeria, Togo, Burkina Faso and other Sahelian countries; and in Southern Africa in Zimbabwe, Mozambique and Botswana. These droughts have caused devastating effects that threaten the ability of the communities to meet their livelihoods and food security needs, conserve biodiversity and maintain good health^{1–4}. Sub-Saharan Africa, is a continent that is home to the world's poorest human populations. Therefore, because of the sensitivity and fragility of its natural environment and its high population growth rate and dependence on environmental resources for their livelihoods, it has suffered most from the adverse effects of climate change^{2,5,6}.

Agricultural systems in western Uganda which are inhabited by predominantly subsistence pastoral and agro-pastoral farmers are mainly rain-fed and are therefore highly vulnerable to climate variability and change^{7–9}. The communities surrounding Lake Mburo National Park (LMNP) in Kiruhura and Isingiro districts

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had experienced frequent severe droughts^{10–14} which threaten their livelihoods and sustainable management of this park. During these periods large herds of cattle invade the park for grazing pasture and foraging plants; and water^{11–14} hence threatening the future survival of this park. Additionally, the livelihoods of the people become severely affected, making them turn to park for its natural resources for survival. The communities in this area have less adaptive capacities to handle adverse effects caused by climate change.

Despite above challenges no studies had been done to determine the economic effects of this calamity on pastoral and agropastoral communities living around LMNP. Yet the economic impact of climate change due to drought was expected to be enormous. It was against the above background that this study was designed to determine economic impact of drought as indicator of climate change on communities living in Kiruhura and Isingiro districts surrounding LMNP, Uganda. It was hoped that once the magnitude of economic loss climate change was causing to smallholder farmers around LMNP was determined, the farmers and the key stakeholders such as formal and informal institutions, the government of Uganda, local government and international development partners would be sensitized about the urgency of the need for them to develop and make communities adopt community based sustainable resilience measures to mitigate the effects of climate change through a participatory approach.

This study was anchored on earlier theoretical frame work that was earlier developed¹⁵. Here drought was expected to cause loss of livestock due to mortality, loss of livestock productivity (loss of milk, weight loss) and livestock mortality, salvage sale of livestock, fall of prices of livestock leading to loss of household income and crop failure leading to high food prices and H/h food insecurity hence loss of livelihoods. Communities affected were expected to develop adaptive measures like migration seeking for alternative sources of livelihoods like employment; and migration of pastoral and aro-pastoral livestock keepers to pristine conservation areas like national parks for pasture and water.

Materials and methods

The study was done around Lake Mburo National Park, Uganda in in the districts of Kiruhura and Isingiro in south-western Uganda (see Fig. 1). LMNP lies between 3° 31' and 31° 04' East and 05° 02' and 07° 30' South. It is at an altitude of 1219–1828 m above sea level measuring about 260 Km²¹¹. It occupies three districts of Mbarara, Kiruhura and Isingiro with the largest part lying in Kiruhura district. It lies in the cattle corridor stretching from Northern Tanzania in the South to the South Western shores of Lake Kyoga, up to Karamoja in the North-East of Uganda¹¹. The study area has a bimodal pattern of rainfall. The average annual rainfall total was about 750–800 mm. The shorter rains fall between March and May, and the long rains start from mid-September to early December. Typically, short dry seasons occur from late December to February, and the long dry season stretches from late May to September¹¹.

A cross-sectional study was done in the districts of Isingiro and Kiruhura in western Uganda. Kiruhura district was a part of the former bigger Mbarara district. Kiruhura was chosen to represent pastoral and agropastoral livestock keeping communities and Isingiro to represent pure crop and crop-livestock farmers. Farmers of both Kiruhura and Isingiro districts were Banyankole ethnic communities. The study was carried out in Nyabushozi County in Kiruhura District and in Isingiro and Bukanga Counties in Isingiro District. The study was carried out in Sanga, Kanyaryeru and Nyakashashara sub counties in Kiruhura District, then Marsha and Rugaga sub counties in Isingiro district.

These study sites were selected to include both the most affected and least affected by prolonged drought. In Kiruhura district, data were collected from Kanyaryeru and Sanga sub-counties in Nyabushozi County, two drought-prone areas. Data were also collected from Rugaga sub-county in Isingiro district, another drought-prone area. For comparative purposes, the studies were also carried out in less drought affected areas. These sites were: Nyakashashara sub-county in Nyabushozi county, Kiruhura district and Marsha sub-county in Isingiro district.

Participatory methods and administration of a detailed structured questionnaire were used to collect data. For both participatory and questionnaire studies, two parishes per sub-county were selected; and from each parish, two villages were selected. A sampling unit was a household from which a man or a woman was chosen. Focus Group Discussions (FDGs) were carried out in all the 20 villages. Three FDGs per village were conducted, which captured women's group, men's group and a mixed group (both men and women). There was a minimum of eight and a maximum of twelve participants for each FDG group. FDGs were conducted in 12 villages in Kiruhura and 8 villages in Isingiro district. Proceedings of the FDGs were recorded for transcription and analysis. The key informants were community experts who had knowledge and understanding of climatic conditions in the community. These included opinion leaders and extension staff, such as district production officers, agricultural officers, meteorologists, veterinary officers, environmental officers, community development officers, Community Wildlife Wardens and the LMNP-Chief Warden.

A questionnaire was administered to selected households with the help of extension staff and village leadership. An equal number of male and female respondents were selected per village. A minimum sample size of 384 households was determined using the equation $N = \frac{Z^2 \cdot P \cdot Q}{e^2}$ adopted¹⁶ where N = minimum sample size, Z = 1.96 at 95% confidence interval, P = Estimated percentage prevalence of 50%, Q = 100-P, and e = acceptable error of 0.05. However, to increase the precision, questionnaires were administered to 400 households: 80 households in each sub-county, 40 households in each parish, and 20 households in each village.

Data were collected using known described participatory methods (key informant interviews and focus group discussions)¹⁷ and a detailed structured questionnaire. Focus group discussions were held with men and women using a checklist of questions. In-depth interviews were purposively done with key informants. A detailed, structured questionnaire was administered to solicit information from farmers covering the one-year period from January–December, 2017. The discussions and interviews were recorded using a tape recorder.

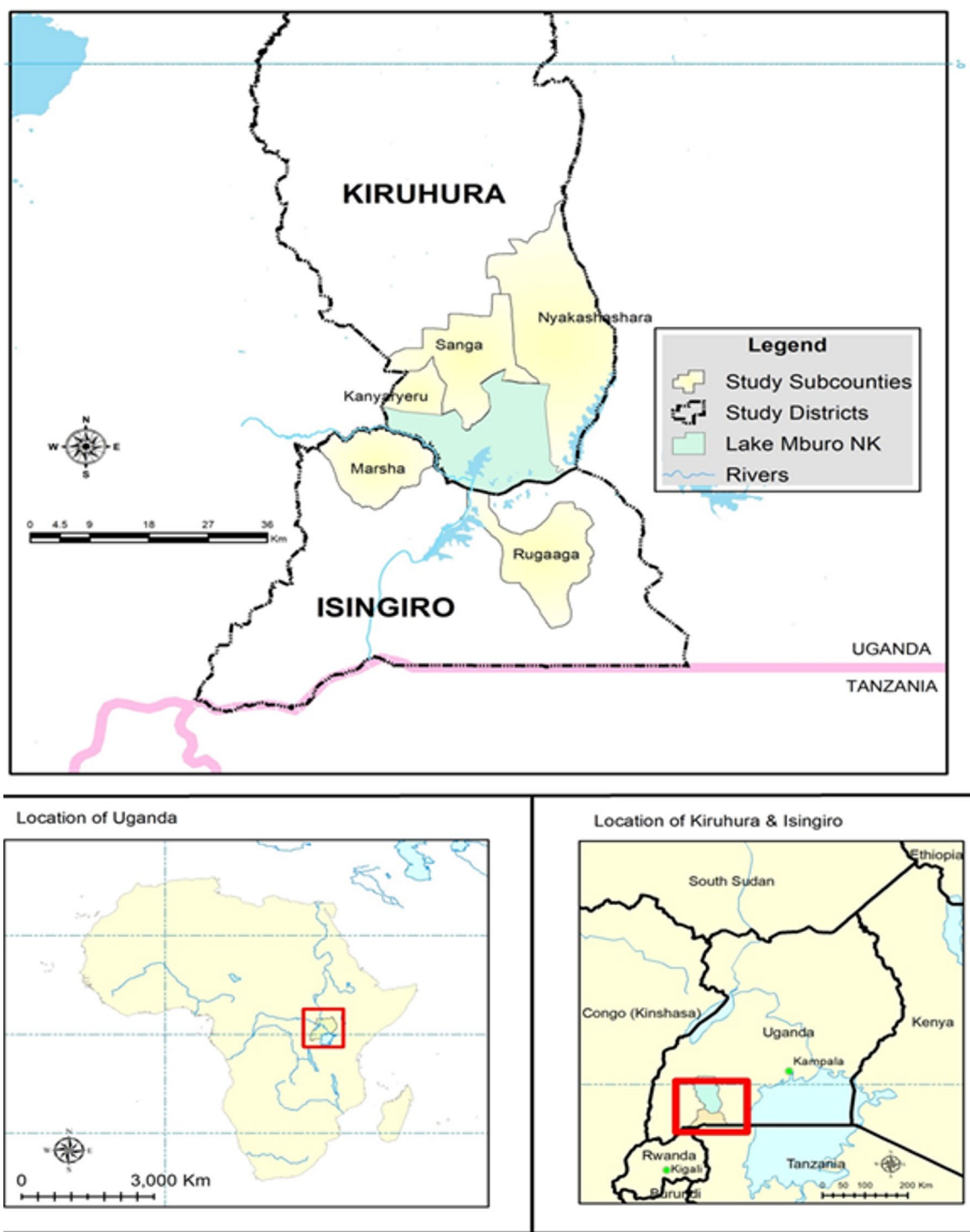


Fig. 1. Maps showing location of study area and sites.

The discussions captured information concerning: livelihoods sources, livelihood assets, sources of income, crop yields, livestock production parameters, livestock herd growth, crop and livestock prices, livestock off-take rates and composition and food consumption patterns (frequencies and composition). A detailed structured questionnaire was administered to determine the socio-economic impact of climate change. A detailed questionnaire was used to verify the information given during participatory study.

Descriptive statistics was used to calculate:

1. The average household changes of crop yield, prices and losses during normal and drought periods
2. The percentage herd age structure composition of cattle and goats.

3. The mean changes in milk yield and prices; ghee making yield and prices during normal seasons and drought periods.
4. The dynamics of mean cattle and goat sale prices during normal and drought periods.
5. The age specific percentage composition of cattle and goats, off-takes, % off-take per age category, age composition of dead cattle and goats; and age specific mortality rates of goats and cattle.
6. The average household dynamics of crop yield outputs, prices and losses during normal and drought periods.
7. Total gross output from agricultural enterprises per household and economic cost per household caused by drought.
8. The frequency and amount of milk consumed and frequency of food consumed per day by children and adults in Kiruhura and Isingiro districts.

The t-test was used to test significant difference of mean variables between districts and between drought periods and normal seasons. The annual total household income and Gross Output from Agricultural Enterprises (TGOAE) was calculated using Excel spread sheet model.

The annual total household income was taken as a summation of income earned from livestock and crop sales and income earned from other activities.

The Gross Output from Agricultural Enterprises (TGOAE) was taken as a summation of Total Livestock Gross Output and Total Crop Output.

Where: Total Livestock Gross output was denoted as $\sum_{i=1}^6 X_i$

- 1 = Milk output
- 2 = Ghee output
- 3 = Cattle sales and herd growth output
- 4 = Goat sales output
- 5 = Sheep sales output
- 6 = Chicken sales output

Total Crop output was taken as a summation of gross output from all crops grown by the household.

The economic cost of climate change per household was taken as summation of costs of crop yield loss, livestock mortality loss, salvage cattle sale loss, milk yield loss and ghee production loss during drought periods.

Where:

Cattle herd mortality loss was taken as sum of different age specific mortality losses. Age specific loss was taken as product of number of livestock (cattle and goats) of specific age group which died due to drought and specific age group market price during that period. For example, specific cattle herd mortality loss due to

drought was denoted as $\sum_{i=1}^5 X_i$ Where by:

- 1 = Mortality loss in calves
- 2 = Mortality loss in steers
- 3 = Mortality loss in heifers
- 4 = Mortality loss in adult cattle
- 5 = Mortality loss in bulls

Similarly, the same was done to determine goat herd mortality loss based on age specific mortality loss (kids, male sub adults, female sub adults, does and bills).

Milk loss per herd was taken as a product of milk yield lost in a herd in liters and market price of milk per liter. Herd milk loss was taken as product of milk loss per lactating cow with ratio of cattle in herd which were lactating during the drought period.

Cattle herd salvage sale loss was taken as sum of different age specific salvage sale losses. Age specific salvage sale loss was taken as a product of number of cattle of specific age group which were salvage sold due to drought and price difference between real market price and salvage sale price during drought. Specific cattle herd salvage

sale loss due to drought was denoted as $\sum_{i=1}^5 X_i$ Where by:

- 1 = Salvage sale loss in calves
- 2 = Salvage sale loss in steers
- 3 = Salvage sale loss in heifers
- 4 = Salvage sale loss in adult cattle
- 5 = Salvage sale loss in bulls

The total annual crop loss was taken as summation of annual losses due to drought per crops grown by household. Crop loss was taken as product of reduction of crop yield in unit measures like Kilogram (Kg) weight, bunches of bananas, tins and pieces and unit price measure of the crop.

Results

The mean H/h size of 5.4 ± 0.2 was the same for both districts. The overall average H/h land size was 40.6 ± 0.5 acres in Kiruhura and 3 ± 0.4 acres in Isingiro. Overall, Kiruhura district had more land than Isingiro district where

Livestock species	Breed	Kiruhura	Isingiro
Cattle	Local	19.2 ± 4	1.5 ± 0.3
	Crosses	30 ± 9.7	1.8 ± 0.6
	Exotic	13.8 ± 4.3	2.6 ± 0.8
	Total	34.3 ± 8.1	2.9 ± 0.5
Goats	Local	15.2 ± 2.8	2.5 ± 0.4
	Crosses	3 ± 0.6	1 ± 0
	Exotic	10.9 ± 5.8	1.9 ± 0.2
	Total	14.5 ± 2.4	3.5 ± 0.4
Sheep	Local	9.4 ± 2.5	1 ± 0
	Crosses	6.5 ± 2.7	1.1 ± 0.06
	Exotic	34.3 ± 27.8	1.8 ± 0.2
	Total	16.7 ± 6.6	2.6 ± 0.2
Pigs	Local	2 ± 0	1.7 ± 0.1
	Crosses	1.1 ± 0.06	3.3 ± 0.8
	Exotic	16.2 ± 5.9	2.4 ± 0.7
	Total	10.6 ± 3.8	4.6 ± 0.8

Table 1. Mean livestock numbers and breed composition per H/h in Kiruhura and Isingiro districts.

Cattle		Goats	
Category	Percentage	Category	Percentage
Bulls	2.4	Adult males	3.7
Steers	2.4	Adult females	43.1
Adult cows	46.5	Sub adult females	19.6
Heifers	24.3	Sub adult males	8.9
Calves	24.4	Kids	24.7

Table 2. The percentage herd age structure composition of cattle and goats in Kiruhura district.

less proportion of land was under crop growing only 17.9% and more was for cattle keeping. While in Isingiro, more land was under crop growing (58.9%).

Livestock kept were mainly cattle, goats, sheep, pigs and chicken. Farmers kept local, crosses and exotic breeds of each species. Details were as shown in Table 1. Cattle kept were 70% Friesian exotics and Friesian–Ankole cross breeds. In Kiruhura 47.6% of the herds were cross-breeds and 44.1% were exotics in Isingiro. The 51.3% of goats were local Mubende breeds, 47.8% were cross breeds of local Mubende goat and Boer goat exotics in Kiruhura and 53.7% were goat cross breeds in Isingiro.

The percentage herd age structure of cattle and goats in Kiruhura district were as shown in Table 2. Table 3 shows the percentage of H/hs depending on certain source for income and contribution of each source to total household incomes in Kiruhura and Isingiro districts. It was shown that Kiruhura was getting very highly significant ($t=20$; $P=0.000005$, $df=21$) more total household income than Isingiro. While, changes in milk yield and prices; ghee making and prices during normal and droughts were as shown in Table 4.

During FGDs and key informant interviews and discussions, it was revealed that climate change was real and if not dealt with, there would be loss of livelihoods. Communities expressed that climate change has caused frequent prolonged droughts leading to livestock deaths, crop failure and water crisis. All communities expressed that they were failing to adopt. Communities had been forced to migrate in search of water and pasture for their livestock. There was rushed salvage sale of cattle to avert the disaster of losing them due to death and raising income for food. The food prices sky rocketted during this period. Women in Kiruhura district reported that there was much reduction of milk production affecting the production of ghee: their main source of their income and also amount available for human consumption. Also, women reported high child school dropped out during this period due to lack of food.

In Kiruhura, cattle off-take was significantly higher ($t=2.73$; $P=0.04$; $df=5$) in drought period than during normal seasons. Cattle sale off-take increased by 129.6% (2.3 times) from 7.1% during normal periods to 16.3% during droughts. Also, cattle crude mortality rates were significantly ($t=3.37$; $P=0.019$; $df=5$) higher in drought periods than during normal seasons. Cattle crude mortality rate increased (73.2%; 1.73 times) from 14.2% during normal periods to 24.6% during droughts. The details of age specific percentage composition of cattle off-takes per age category, age composition of dead cattle and age specific mortality rates in Kiruhura were as shown in Table 5. Cattle prices significantly dropped during drought periods: for local Ankole ($t=3.73$; $P=0.013$, $df=5$) and cross bred ($t=2.59$; $P=0.048$, $df=5$). The cattle prices dropped by 46.8% (0.5 times) in Kiruhura district. Details of dynamics of cattle prices during normal and droughts periods were as shown in Table 6.

Source of livelihoods	Kiruhura			Isingiro		
	% of dependant H/hs	Each source contribution (UGX)	% source contribution to H/h income	% of H/hs	Source contribution (UGX)	% source contribution to H/h income
Cattle sales	10.2	1,228,125	13.1	8.7	1,500,000	64.1
Milk sales	12.1	416,111	4.4	0	275,000	11.8
Ghee sales	7	1,200,000	12.8	2.7	0	0
Crop sales	19.7	370,924	4	10.3	174,667	7.5
Goat sales	5.1	400,714	4.3	5	90,000	3.8
Sheep sales	1.9	400,714	4.3	6.6	200,000	8.5
Chicken sales	0.6	566,666	6	6	0	0
Charcoal burning and selling	2.5	682,000	7.3	0	0	0
Fishing	3.8	519,333	5.5	6.3	0	0
Rental income	3.2	448,333	4.8	4.4	0	0
Uprooting <i>Acacia</i> species	1.2	150,000	1.6	4.8	0	0
Tailoring	1.9	355,329	3.8	9.8	0	0
Building	2.5	552,800	5.9	0.8	0	0
Weaving and craft work	3.2	70,000	0.7	1	0	0
Land renting	4.5	80,000	0.9	1.9	0	0
Employment salary	2.5	471,857	5	1.1	0	0
Retail trading	10.8	281,880	3	4	65,000	2.8
Driving and motor cycle riding hire	2.5	241,667	2.6	6	0	0
Providing casual labour	2.5	45,500	0.5	5.6	0	0
Brick laying	1.3	294,000	3.1	3.1	0	0
Remittances from off farm from relatives	0.6	637,352	6.8	4.2	35,000	1.5
Others	0		0	3.4		0
Total	UGX	9,367,591			2,339,667	
	USD	2,590			646.9	

Table 3. Percentage of H/hs depending on certain source for income and contribution of each source income to total household incomes (UGX) in Kiruhura and Isingiro districts. *Exchange rate:1 United States Dollar (USD) = UGX 3,617¹⁸.

Item	Season	Kiruhura	Isingiro
Average milk yield per cows (litres)	Wet	8.67	2.29
	Dry	4.14	2.06
	Drought	1.72	1.12
Average milk price (UGX)/litre	Wet	650	510
	Dry	1,039	970
	Drought	1,247	1,460
Ghee making (Litres/Kg per week)	Wet	33	1.6
	Dry	15.2	0
	Drought	5	0
Ghee prices (UGX/Kg)	Wet	3,475	3,297
	Dry	4,647	4,712
	Drought	6,223	6,075

Table 4. Changes in milk yield and prices; ghee making yields and prices during wet, normal dry season and droughts. *Exchange rate: 1 United States Dollar (USD) = UGX 3,617¹⁸.

In Kiruhura, goat off take did not change significantly ($t=0.08$; $P=0.093$; $df\ 4$) during drought periods. While goat crude mortality rate decreased significantly ($t=2.73$; $P=0.049$; $df\ 4$) during drought periods by 47.2% (0.5 times) from 21.4% to 11.3%. Details of age specific percentage composition of goat off-takes, % off-take per age category, age composition of dead goats and age specific mortality rates in Kiruhura were as shown in Table 7. Goat prices increased 2.1 times both in both districts. Details of goat sale prices during normal and during droughts in Kiruhura and Isingiro districts were as shown in Table 8. It was shown that goat prices very

Age category	Cattle off- take				Cattle mortality			
	% composition of off- take by age category		% off-take per age category		% age composition of dead cattle		% age specific mortality rates	
	Normal	Drought	Normal	Drought	Normal	Drought	Normal	Drought
Bulls	17.2	11.1	50	74	3.4	5	20	50
Steers	27.6	14.1	80	94	1.7	4	10	40
Adult cows	34.5	49.4	5.2	17.3	23.4	33.7	7.2	17.8
Heifers	20.7	25.4	6	17	11.6	15.8	6.8	16
Female calves	0	0	0	0	32.5	20.8	38	42
Male calves	0	0	0	0	27.4	20.8	32	42

Table 5. Percentage dynamics cattle off-takes, off-take per age category, age composition of dead cattle and age specific mortality rates of normal and droughts in Kiruhura district.

Category	Normal price UGX)		Drought price (UGX)		% price decrease	
	Local	Crosses	Local	Crosses	Local	Crosses
Bulls	758,333	850,000	407,272	384,615	46.3	54.8
Steers	780,000	906,000	770,000	875,000	1.3	3.4
Adult cows	750,000	761,539	530,833	328,889	29.2	56.8
Heifers	690,000	760,526	564,285	690,000	18.2	9.3
Female calves	866,668	628,571	485,714	435,000	44	30.8
Male calves	316,667	270,000	130,700	218,500	44.2	31

Table 6. Changes of cattle prices (UGX) during normal and droughts in Kiruhura district. *Exchange rate: 1 United States Dollar (USD) = UGX 3,617¹⁸.

Age category	Goat off take				Goat mortality			
	% composition of off take by age category		% offtake per age category		% age composition of dead goats		% age specific mortality rates	
	Normal	Drought	Normal	Drought	Normal	Drought	Normal	Drought
Adult males	14	7.3	51.7	34.5	3	5.6	17.2	17.2
Adult females	34.9	41.8	11	16.9	13.3	13.2	6.6	3.5
Sub adult females	14	15.3	9.7	13.5	20.7	16.8	22.6	9.7
Sub adult males	37.2	32.7	57.1	64.3	14.1	11.2	33.9	14.3
Kids	0	2.9	0	2.1	48.9	53.2	42.3	24.4

Table 7. Percentage age specific percentage composition of goat off takes, % off-take per age category, age composition of dead goats and age specific mortality rates in Kiruhura district.

Category	Kiruhura			Isingiro		
	Normal	Drought	% price increase	Normal	Drought	% price increase
Adult males	82,500	152,500	84.8	70,000	150,000	114.3
Adult Females	86,250	175,000	102.9	80,000	150,000	87.5
Sub-adult males	65,625	151,250	130.5	50,000	100,000	100
Sub-adult females	65,909	152,455	131.3	45,000	100,000	122.2
Kids	68,000	137,000	101.5	30,000	60,000	100

Table 8. Goat sale prices (Ug. Shs) during normal and droughts in Kiruhura and Isingiro districts. *Exchange rate: 1 United States Dollar (USD) = UGX 3,617¹⁸.

Crop	Normal yield	% Drop yield	Normal Price (UGX)	% price increase	Gross output (UGX)	Amount of crop loss (UGX)
Bananas in bunches	208	81.8	5,986	82.4	1,245,088	1,018,482
Maize in Kg	328.6	15.8	733	68.2	240,847	38,054
Coffee in Kg	120	70.8	3,585	97.2	430,200	304,582
Beans in Kg	62.5	78	1,231	150.1	76,920	59,998
Millet in cups	2.9	31	419	52.9	1,215	377
Sorghum in cups	1.9	31.6	225	211.1	428	135
Pieces of sugarcane	4.5	11.8	225	385.3	1,014	120
Tomatoes (Kg)	2	5.9	211	16.1	422	25
Heads of cabbages	2	6.7	300	133.3	600	40
Kg of cassava	1.8	7.7	833	68.1	1,498	115
Irish potatoes in tins	2.4	33.3	2,807	148.5	6,737	2,243
Peas in tins	1	0	4,333	38.5	4,333	0
Sweet potatoes in tins	2.5	0	2000	194.3	4,906	0
Total (UGX)					2,014,207	1,424,170
Total (USD)					556.9	392.8

Table 9. The average household amount dynamics of crop yield, prices (UGX) and losses during normal and drought periods in Kiruhura district. * Exchange rate: 1 United States Dollar (USD) = UGX 3,617¹⁸.

Crop	Normal yield	% Drop yield	Normal Price (UGX)	% price increase	Gross output (UGX)	Amount of loss (UGX)
Bananas in bunches	368.9	73.4	5,900	137.3	2,176,510	1,597,558
Maize in Kg	416	100	700	362.6	291,200	291,200
Coffee in Kg	347.4	100	2,500	0	868,482	868,482
Beans in Kg	486.5	100	1230	52.4	598,390	598,390
Millet in cups	34.4	11.1	425	277.8	14,640	1,625
Sorghum in cups	45.1	0	230	215	10,362	0
Pieces of sugarcane	36	100	250	300	9,000	9,000
Tomatoes (Kg)	26.9	100	211	18	5,678	5,678
Heads of cabbages	6	0	300	120	1,800	0
Kg of cassava	14.5	0	850	65	12,300	0
Irish potatoes in tins	89.1	33	1,838	0	163,678	54,014
Peas in tins	29.5	100	4500	42	132,585	132,585
Sweet potatoes in tins	12.4	0	2,000	300	24,854	0
Total (UGX)					4,309,478	3,558,532
Total (USD)					1,192.5	983.7

Table 10. Average household amount dynamics of crop yield, prices (UGX) and loss during normal and drought periods in Isingiro district. *Exchange rate: 1 United States Dollar (USD) = UGX 3,617 UGX.

highly significantly increased during drought periods: Kiruhura ($t = 18.5$, $P = 0.000005$; $df 4$) and Isingiro ($t = 6.6$; $P = 0.003$; $df 4$).

The average H/h dynamics of crop yields, prices and losses during normal and drought periods in Kiruhura and Isingiro were as shown in Tables 9 and 10 respectively. The total crop output during normal seasons was significantly ($t = 2.23$; $P = 0.045$; $df 12$) higher in Isingiro than Kiruhura district. In Isingiro bananas, coffee, beans, maize, Irish potatoes and peas contributed 68.5%, 27.3%, 18.9%, 9.2%, 5.1% and 4.2% of total crop household gross output respectively. While in Kiruhura bananas, coffee, maize and beans contributed 61.8%, 21.4%, 12% and 3.8% of total crop household output respectively. Also, there was significantly ($t = 2.5$; $P = 0.28$, $df 12$) more crop losses in Isingiro than in Kiruhura. Seventy-point seven percent and 82.4% of crop gross output was lost in Kiruhura and Isingiro respectively due to drought. There was a highly significant increase of crop prices during drought periods: in Kiruhura ($t = 3.7$; $P = 0.003$, $df 13$) and Isingiro ($t = 2.5$; $p = 0.028$; $df 13$). However, there was no significant ($t = 0.53$; $P = 0.6$, $df 13$) difference in increase of crop prices between the two districts.

Total Gross Output from Agricultural Enterprises (TGOAE) and economic cost per H/h caused by drought in Kiruhura and Isingiro districts were as shown in Table 11.

The milk output was 83.8% of TGOAE in Kiruhura, while crop output was 67.6% of TGOAE in Isingiro district. The economic cost due to drought caused 58.7% and 58.1% of TGOAE in Kiruhura and Isingiro districts respectively. The economic cost due to drought was 83. 5% due to milk loss in Kiruhura and 96% was due to crop loss in Isingiro. The frequency and amount of milk consumed and frequency of food consumed per day by children and adults in Kiruhura and Isingiro districts were as shown in Table 12.

Gross output from agricultural enterprises			Economic cost of drought		
Variable	Kiruhura	Isingiro	Variable	Kiruhura	Isingiro
Milk output	53,924,344	275,000	Milk loss	31,520,000	148,176
Ghee output	2,772,000	0	Ghee production loss	1,495,200	0
Cattle sales and herd growth output	4,082,806	1,500,000	Cattle mortality loss	2,205,409	0
Goat output	554,442	90,000	Cattle salvage loss	1,105,335	0
Sheep output	400,714	200,000	Crop loss	1,424,170	3,558,532
Chicken output	566,000	0	Total (UGX)	37,750,114	3,706,708
Crop output	2,014,207	4,309,478	Total (USD)	10,437.4	1,024.8
Total (UGX)	64,314,513	6,374,478			
Total (USD)	17,782.1	1,762.40			

Table 11. TGOAE per household and economic cost per H/h (UGX) caused by drought in Kiruhura and Isingiro districts. *Exchange rate: 1 United States Dollar (USD) = UGX 3,617¹⁸.

Item	Group	Kiruhura		Isingiro	
		Normal	Drought	Normal	Drought
Frequency of milk consumed per day	Children	3	1	2	0
	Adults	2	0	1	0
Average milk (liters) consumed per day	Children	5	2	2.3	0
	Adults	3	0	2	0
Frequency of food consumption per day	Children	2.5	2	2	1
	Adults	1.5	1.9	2	1

Table 12. The frequency and amount of milk consumed and frequency of food consumed per day by children and adults in Kiruhura and Isingiro districts.

Discussion

The household size and mean landholdings found in this study in Kiruhura was lower than those previously reported^{10,19}. The H/h size was in agreement with average household size in Uganda estimated to be 5 persons (UBOS, 2019) and slightly higher than 4.2 persons per H/h (UBOS 2024). Kiruhura district land holding per household was 13.3 times more than that in Isingiro district. Most of the land in Kiruhura was for livestock keeping, whereas in Isingiro it was for crop growing.

Local, cross and exotic breeds of cattle, goats, sheep, pigs and chicken were kept (Table 1). Cattle kept were mainly exotic Friesian breeds and Friesian-Ankole cross breeds. In Kiruhura, cattle herds were mainly cross-breeds and were Friesian exotics in Isingiro. These findings indicated that farmers in the study area were geared towards improvement for milk yield production. Climate change was therefore becoming bottleneck for achieving this goal.

The cattle were kept on smaller pieces of in Isingiro district (1 cattle unit per 0.4 acres of land) than in Kiruhura district (1 cattle unit per 1 acre of land). In Kiruhura, cattle were more free-ranged on pasture. While in Isingiro, cattle keeping was on small scale, whereby an adult cow, a sub-adult either heifer or steer; and calf were being kept at any time. The steers were fattened for sale and in-calf heifer raised for replacement or sale. The cattle were supplemented by feeding on crop after- harvest residues mainly of bananas, beans and maize stover.

The cattle herd structure in Kiruhura (Table 2) had a high proportion of female cattle, which was purposely geared towards production of calves for herd growth and milk. Similar observation had earlier been made in this study area¹⁹⁻²¹ and among the pastoralist Bakungu in Buliisa district, Uganda²¹. This has been observed with pastoral herds elsewhere in sub-Saharan Africa²². This was contrary among cattle herds in crop-livestock systems in eastern Uganda in Teso Region²³ and Tororo district²⁴ and in Ethiopia²⁵ where cattle herds were to support traction for crop production. This means that adaptive ameliorative measures developed to curb climate change should take care of these cultural differences for purpose of cattle keeping.

In the study area, goat keeping was for meat production where local Mubende breed; and cross breeds of Exotic Boer and local Mubende goats were kept. It was also found that non- traditional livestock keeping of sheep, pigs and chicken were being undertaken in this area. This was an attempt of diversification sources of income and also as a strategy of empowering the disadvantaged groups particularly the women and children; narrowing the poverty gender gap and coping with the effects of climate change.

The mean total household income in Kiruhura (USD 2,590) was four times greater than that earned in Isingiro district (USD 646.8.). This occurred because sources of household income in Kiruhura were more diversified than those of Isingiro (Table 3). The sources of income were from sale of cattle, milk, goat, sheep and crops. In addition, in Kiruhura, income was also being earned from sale of ghee, chicken and charcoal; and from fishing.

In Kiruhura, more income was earned from charcoal sales (Table 3). Lake Mburo National Park and its surrounding rangelands were invaded by *Acacia hokii* as a result of frequent burning and overgrazing¹¹. Frequent

burning was done towards the end of the dry season so as to avail lush pasture for livestock grazing during early rainy season. This caused human-livestock-wildlife conflicts because *Acacia hokii* bush had encroached, replacing pasture. Uprooting *Acacia hokii* had therefore been recommended by UWA¹¹ as a measure to check *Acacia* bush encroachment. The communities took advantage of this initiative and resorted to uprooting and cutting *Acacia* for charcoal making. The increased income earned from the sale of charcoal then became an adaptive strategy to mitigate the effects of drought. Similar observations of charcoal burning for sale had been recorded elsewhere in Africa in Zimbabwe²⁶, Senegal²⁷ and in Botswana²⁸ where production of livestock and crops had dropped due to climate change.

During wet seasons, annual crop yields per household in Kiruhura district were high for bananas, beans and maize (Table 9). While in Isingiro crop yields were good for bananas, beans, maize, Irish potatoes and peas (Table 10). Coffee was a major cash crop grown in both districts. After meeting home consumption demands, the crop surpluses were sold.

The mean household Total Gross Output from agricultural enterprises (TGOAE) (Table 11) in Kiruhura (USD 17,782.1) was 10.1 times more than that was earned from Isingiro district. This showed that Kiruhura was in good position in responding to climate change shocks. Cattle was a major source (94.5%) of TGOAE; of which milk was major output contributing 88.7%. This finding agreed with what was earlier reported for dairy production enterprises in South Western Uganda²⁹. While in Isingiro district, crops contributed 68.7% of TGOAE.

Earlier it was reported that climate change in the study area was real and the communities had failed to cope with it¹³. There was high mortality of cattle, reduction of milk yield which affected ghee making and amount milk available for children, high salvage sale of cattle to avert the disaster of losing them due to death and increasing need to raise income for buying food. There was total crop failure leading to famine and increased food prices.

Climate change caused economic cost per H/h (Table 11) 10.1 times more in Kiruhura (USD 10,437.4) than in Isingiro (USD 1,024.8). Drought caused economic loss of 58.7% and 58.1% of TGOAE in Kiruhura and Isingiro respectively. In Kiruhura, it caused 96.2% loss of output from cattle enterprises due to loss of milk production (Table 4). It caused 80.2% decrease in milk yield, which caused 91.8% increase of milk prices. This greatly affected the profitability of cattle enterprises and the ability of farmers in this geographical location to meet their livelihoods. The aspirations of farmers to modernize their dairy industry according to the Uganda NDP III goals³⁰ and attaining United Nations Sustainable Development Goals³⁰ were shattered. The cattle farmers in this area should therefore adopt climate change mitigation measures for production and conservation of forages, having sustainable water catchment and storage facilities with cheap solar water pumps. Similar adaptive strategies have been advocated in Somalia³¹ and in the Borana zone, south Ethiopia³².

A decrease in milk production disrupted ghee production. There was 84.8% reduction in ghee production in Kiruhura district (Table 4). Ghee production which during normal periods constituted 4.3% of TGOAE. This was a major source of income for women. There was 74.1% increase in ghee prices.

In Kiruhura, cattle sale off-take increased by 2.3 times during drought periods (Table 5). While cattle crude mortality rate was increased 1.73 times during drought periods. Mortality occurred in all age groups due to lack of pasture. Mortality loss caused 5.8% of EC caused by drought. However, the crude mortality found in this study area was much lower than what was earlier reported¹⁹. Elsewhere many cattle deaths due drought had been observed in Narok county in Kenya³³ and in Southeast Nigeria³⁴.

Owing to the panic caused by death of cattle, poverty and the need for money to buy food, cattle were sold off at salvage low prices. There was decrease of prices of cattle of all age categories (Table 6). Cattle prices dropped by 46.8%. There was 2.3 times increase in cattle sale off-take during droughts in Kiruhura. Salvage sale loss contributed to 2.9% to economic cost due to drought in Kiruhura (Table 11). In Kaabong district, Karamoja region in Uganda, salvage sale losses contributed 7.2% of economic cost due to cattle diseases per household³⁵. Elsewhere these effects were also most felt among the pastoral communities in Kenya^{36,37}, in Ethiopia^{38–40}, in Burkina Faso⁴¹ and in Nigeria³⁴. Earlier work done in the study area¹⁹ showed that the economic cost of drought among cattle in this area was less severe. The higher economic cost observed in this current study was due to increased losses from milk output as local Ankole cattle breed was being improved using exotic Friesian Dairy breed for milk production.

In Isingiro and Kiruhura, drought crop losses constituted 96% and 3.8% respectively to economic losses caused by climate change. Climate change caused 70.7% and 82.6% of crop output loss in Kiruhura and Isingiro respectively. In Isingiro, crop losses caused by drought was very severe blow to the survival of households. They were solely depended on crops for livelihoods (Tables 3, 11). Isingiro was previously known as the food basket of western Uganda.

Due to scarcity of food and their high demand, the prices of food increased (Tables 9, 10). Isingiro was the worst hit because it mainly depended on crops for livelihoods. This finding was in agreement with what was earlier reported⁴² in the same district. This situation forced households to sell their property, like land and roofing iron sheets or to contract loans from various microfinance institutions in order to procure food. In some households, men abandoned their homes after failing to pay their loans. The sale of family assets often resulted into domestic violence. Earlier study⁴³ done in Ethiopia confirm these findings. The distortion of food prices and supply caused by climate change in this area was also being exacerbated by the current Ukraine-Russian war⁴⁴. The above highlighted social distortions caused by climate change in the study area were in agreement with what has already been extensively discussed⁴⁴.

Elsewhere in the Okavango region of Botswana, drought had a high reduction on crop yields, especially maize and sorghum⁴⁴. In East Africa, reduction in rainfall by 50–150 mm caused drastic reduction in maize and sorghum yields³⁷. Drought caused total crop loss in Somali region in Ethiopia³⁹ and among agro-pastoral households in Southeast Nigeria³⁴.

In this study, it was shown that sorghum, millet, cassava, sweet potatoes and cabbages could withstand effects of drought in the study area. Growing of these crops should be promoted in the study area as adaptive measure to

proof crop losses caused by climate change. Elsewhere, in Sub-Saharan Africa, this has been promoted as climate change resilience proof measure^{34,45}.

Income losses from climate impacts were felt more in Kiruhura than in Isingiro (Table 11). Kiruhura lost (USD 10,437.4) 10.2 times more than Isingiro (USD 1,024.8). The economic cost due to drought found by this study in Kiruhura was twice the amount of losses earlier reported²⁰. This occurred because most of the economic losses (83.5%) were from milk losses. This was due to a shift of some H/hs of the Bahima cattle keeping community in the study area from being purely pastoralists to sedentary agro-pastoralists who were now keeping improved dairy cattle for milk production. With this newly adopted production system, climate change has become a very sensitive factor. Drought affects pasture and water availability which had severely affected milk production hence the profitability of cattle enterprises. There was a complete shift from using mobility as an adaptive strategy during harsh dry periods⁴⁶.

The results reveal that goats thrived well during droughts in the study area. The mortality rates decreased by 89.4% (Table 7). The prices of goats more than doubled (Table 8). The goats were doing well due to plenty of *Acacia hokii* bushes. Goat keeping should therefore be promoted in the study area to act as drought proof measure and as well as being a biological control for *Acacia hokii* bush pasture weed in Kiruhura district. Off-take rates of goats were not affected by drought. Similar findings had previously been reported in Bostwana⁴⁴.

Climate change affected crop yields making food insecurity inevitable^{6,47,48}. This study affected food consumption trends during droughts (Table 12). There was drastic reduction in milk production in Kiruhura. Milk consumption among children also reduced to zero in Isingiro and by 60% in Kiruhura. There was no milk consumption among adults in both Isingiro and Kiruhura during drought periods. Similar effects had also been observed in Burkina Faso⁴² where milk, which used to be the staple food by farmers, was replaced by cereals due to reduction of milk production caused by climate change. The frequency of meal consumption was reduced to one meal per day. This risked both children and adults becoming malnourished. Climate change has caused global food insecurity^{4,45,49} especially among African people^{6,32–34,45,47,48,50–52}. In the study area, prices of food, especially cereals, increased during drought periods (Tables 9, 10). These findings indicate that, in the future, to alleviate food shortages as climate change intensifies, external support may be solicited to provide food relief.

In conclusion, it becomes apparent that the study area had suffered a high brunt due to climate change with Isingiro district suffering most because it had total crop failure hence food insecurity. Besides, Isingiro households were poor, could not handle climate change shocks. Kiruhura district suffered high economic losses due to drought, but it was in a much better position to handle climate change shocks. This was because its H/hs had diversified sources on livelihoods. Further farmers in the study area needed to be sensitized about the impact and urgency needed to mitigate and develop adaptive resilience measures to address impacts of climate change. The adaptive strategies would involve modifications of crop and livestock production and management systems, breeding of local drought resistant crop and livestock breeds, designing and promoting positive institutional and policy changes; and improving the farmers' perception and adaptive capacity towards climate change. Crop farmers should plant drought resistant and early maturing crops. Low-cost water harvesting and storage infrastructures should be adopted and irrigation done using affordable solar powered pumps. Cattle farmers in this area should also adopt technologies for production and conservation of forages. Given that drought has become a frequent cyclical event, an early warning system should be developed. For this to be possible climate services from Uganda National Meteorological Department need to be put in place. Drought early warning systems, when adopted, will enable cattle farmers to destock early by selling them; and for crop farmers to plant drought resistant and early maturing crops when anticipating drought. Goat-keeping should be promoted, because goats thrive well during this challenging drought periods. Broadly, climate change mitigation measures should target reduction of livestock green-house gases (carbon dioxide, methane and nitrous oxide) emissions. This would involve carbon sequestration by vegetation planting of both trees and grasses. To reduce methane and nitrous oxide, there was a need of improvement of manure management by subjecting cow dung to anaerobic fermentation for methane gas production for H/h use for lighting and cooking; and production of fertilisers for improving crop and pasture production. Through a multi-stakeholder participatory approach using a Theory of Change, formal and informal institutions, farmers and major stakeholders should be sensitised and made to design climate change adaptation, mitigation and resilience measures. This should be developed using decentralized Climate Change Smart Action Labs platforms.

Data availability

Data is available on request with the corresponding author on email: mocaido2@gmail.com.

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Author contributions

JIN: Participated in conception and design of the study, preparation of data collection tools; data collection, entry and analysis; and manuscript writing MO: Participated in conception and design of the study, preparation of data collection tools; data collection, entry and analysis; manuscript writing and now corresponding author.

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Declarations

Competing interests

The authors declare no competing interests.

Ethics approval

This study obtained two ethical approvals from Makerere University School of Social Sciences Research Ethics Committee (MAKSS REC) under the protocol number MAKSS REC 06.17.063 and Uganda Council for Science and Technology (UNCST) with Research Registration Number SS 4383. Information regarding the role of each participant was explained. Informed signed consent was obtained from all respondents or from their legal guardians. All research methods were carried out in accordance with relevant guidelines and regulations for doing social research as approved by Makerere University School of Social Sciences Research Ethics Committee and Uganda National Council of Science and Technology.

Consent for publication

All authors have consented to the publication of this manuscript in this Journal.

Additional information

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