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Typologies and determinants of coping responses to forage and water scarcity among livestock farmers in south-western Uganda: Does gender matter?

David Mfitumukiza [a,b,1,*], Ronald Twongyirwe [c,1,*], Gordon Y. Mwesigwa [b], Esther Kebirungi [d], Viola Nilah Nyakato [e,f], Consolata Kabonesa [g]

[a] *Department of Geography, Geoinformatics and Climatic Sciences, Makerere University, PO Box 7062, Kampala Uganda*
[b] *Stewardship Institute of Environment and Natural Resources, PO Box 131718, Kampala Uganda*
[c] *Department of Environment and Livelihoods Support Systems, Faculty of Interdisciplinary Studies, Mbarara University of Science and Technology, PO Box 1410, Mbarara, Uganda*
[d] *Faculty of Medicine, Mbarara University of Science and Technology, PO Box 1410, Mbarara Uganda*
[e] *Faculty of Interdisciplinary Studies, Mbarara University of Science and Technology, PO Box 1410, Mbarara, Uganda*
[f] *Nordic Africa Institute, Uppsala, Sweden*
[g] *School of Gender and Women Studies, Makerere University, PO Box 7062, Kampala Uganda*

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A B S T R A C T

Context specific evidence, including understanding of gender–differentiated responses to shocks and stresses, could bolster adaptation and resilience building amongst agricultural communities, amidst a changing climate. However, information derived from such a perspective is currently deficient in livestock production literature. In this study, we use a gendered lens to assess responses of male– and female-headed livestock dependent households to drought–induced water and forage shortages in south-western Uganda. The study specifically addresses four questions: (i) What are the gender differentiated characteristics, and typologies of households involved in livestock production? (ii) How do the gender disaggregated household characteristics influence the perceived extent of effects of water and forage shortage? (iii) How do gender disaggregated household characteristics influence coping strategies to water and forage shortages? (iv) What are the gender–based roles in coping with water and forage shortages? Data were collected from livestock-dependent households using a semi-structured questionnaire. The data were analysed and presented using various techniques including descriptive and inferential statistics (e.g., principal components and cluster analyses, and ordered probit modelling). Results show that livestock production is persistently male-dominated, with female-headed households poorer and more likely to earn less ($p < 0.05$) from livestock farming than their male-headed counterparts. Female heads of households were about 10 years older than their male-head counterparts, but they are more likely to be widows or single ($p < 0.05$). Marital status and number of male employees were the most important factors for divergent views on the extent of water and forage shortage. Yet, household size and income were most important for coping with water and forage shortages. Coping with drought effects exhibited a gendered trend, and traditional gender roles in livestock management are changing. Our findings provide a basis for gender–responsive policy

* Corresponding authors.
E-mail addresses: dmfitumukiza@gmail.com (D. Mfitumukiza), rtwongyirwe@must.ac.ug (R. Twongyirwe).
[1] Joint first authors.

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and practice interventions – in the changing contexts – for enhanced involvement of women in livestock production-based livelihoods.

Introduction

Drought ranks first amongst all climate hazards in terms of the number of people directly affected due to its cascading effects that are often difficult to anticipate, measure and manage [1]. The most affected are the socio-economically vulnerable households and communities [2]. Drought increases the vulnerability of such communities through its associated reduction in surface and ground-water resources, which leads to a decrease in water supply, deterioration in water quality as well as reduced crop productivity [3]. Besides, vulnerability is changing: A drought event today may be of similar intensity and duration as a historical event but the impacts will likely differ markedly because of changes in socio-ecological characteristics, in a given location, such as the nature of human activities and associated land use and land cover dynamics. For example, loss of wetland and other natural vegetation cover and biodiversity due to human-induced degradation will leave communities exposed to drought due to loss of ecosystem services (e.g., water quantity and quality).

The impacts of drought impinge upon different lives and livelihoods within agrarian populations in complex ways including unemployment, erosion of assets, income decrease, increased livestock mortality, poor nutrition and general decrease in impact absorptive capacity [4]. Dependency on rain-fed agriculture in countries such as Uganda exacerbates vulnerability to drought effects on productivity. As a corollary, drought adds intricacy to household livelihood (in)security [5]. Worsening impacts of drought such as crop failure and decline in animal yields undermine farmers' core source of income and resources to meet their basic needs including access to food, health facilities, educational opportunities, housing, among others.

The impacts of and responses to drought are shaped and constrained by gender relations and patriarchal social structure. The extent and impacts of drought manifest differently among men and women [2]. For example, the impacts of drought have been shown to undermine the ability of women to access resources, acquire assets, and engage in viable income-generating activities [6]. In East Africa, the existing gender inequalities that women experience put them in a more vulnerable situation with respect to drought and other hazards compared to their male counterparts. This includes structural inequalities in production resources such as land ownership and control, rooted in social-cultural norms and traditions that marginalize women [7].

Although livestock farming offers livelihood to both men and women, it presents gendered production challenges and perspectives on drought and coping strategies are likely to be different (our study). Livelihood focused studies show that gendered patterns are critical considerations in understanding and responding to drought phenomenon and other climate related hazards [8]. Such patterns include gender differentiated household level deployment of assets to maintain livelihoods in response to drought shocks and stresses. The assets drawn upon cut across natural- (e.g., water), physical- (e.g., farming equipment), financial-, social- (e.g., networks) and human- (e.g., labour) categories [9]. Variations in these asset capabilities between men and women ultimately influence the activities in which they can engage in [2].

Gender influences the capacity to adapt to drought due to unequal power relations and restrictions, many of which are socially constructed [6]. Gender-based disparities in adaptive capacity to drought are manifested through the different ways individuals and households can sustain their livelihoods from available and accessible assets [10]. For example, disproportionate limited access, ownership and control of land by women, due to discriminatory inheritance practices, disempowers them from leveraging land assets in coping with climate change impacts [11]. Accordingly, a changing climate presents distinct implications on gender–related livelihood characteristics among livestock farmers. This includes creating and/or changing new gendered demands and challenges in terms of coping responses to drought. Hence the need for gender analysis of such livelihood processes to help in understanding and providing context of household response and coping and/or adaptive capacity to drought shocks and stresses. In this study, we look at coping and/or adaptive capacity as the ability of a system to respond to and recover from a stress or shock that has the potential to alter the structure or function of the system [12]. We tie coping and/or adaptive capacity to a socio-ecological system where people are active individuals with social ties [13]. While there have been attempts to support livestock farmers in Uganda to manage drought (and other hazards), the efforts have not been intentionally designed to meet gender differentiated needs and disparities. The available drought response strategies have implications on gendered perceptions, choices and roles, which consequently influence the process of vulnerability reduction. There is a need to move beyond the number of men and women benefiting from drought management interventions: It is important to unpack and understand the differentiated gender relations and roles in drought adaptation response [14]. Otherwise, decision making will continue to be constrained by a lack of understanding of specific considerations that enable or inhibit gender–responsive adaptation action.

Unfortunately, there is inadequate actionable localised information to support gender–differentiated decision–making processes and interventions for drought responses, especially among rural livestock dependent household communities in Uganda. Yet, information on gender roles, responsibilities, needs and perceptions is critical for targeted strategies for climate resilient livestock production [15]. Understanding differences in perceptions, roles and responses of gender groups (and their relations) to climate related impacts and risks provides a basis for dealing with such challenges including reducing vulnerability. In that way, proactively and appropriately designed gender responsive adaptive capacities to build resilience to drought shocks and stresses at the local community and household level can be deployed.

In this study, we use a gendered lens to assess responses of male and female heads of households to drought and its related impacts on livestock production systems. Gender is used as a relational variable where gender differences are socially constructed and reflect the social and cultural norms of a society [8]. The paper takes into account the intersections of gender with age, education, marital status, household head, household labour, household size, and income variables that shape social and gendered positions and lived experiences of women and men. A gender lens is important for critical assessment of historical, political, social, cultural and contextual factors that shape power relations, gender roles and decision-making process [16]. In this study, the focus is on offering insightful entry points (not delving into details) for understanding differentiated adaptation responses to drought effects and associated power dynamics amongst livestock farmers [16]. Such a perspective is currently lacking in livestock production literature in Uganda to the best of our knowledge.

The paper aims to generate information to influence and help in shifting perceptions and open up for gender–integrated practices of managing drought impacts in rural smallholder livestock production systems. The study attempts to answer four questions: (i) What are the gender differentiated characteristics, and typologies of households involved in livestock production? (ii) How do the gender disaggregated household characteristics influence the perceived extent of effects of water and forage shortage on a household? (iii) How do gender disaggregated household characteristics influence coping strategies to water and forage shortages? (iv) What are the gender–based roles in coping with water and forage shortages? The rest of the paper is organized as follows. In Section `Study area, data, materials and methods', we describe the study area and methods used in this investigation. We then present the main findings, discussion of results and conclusions respectively.

Study area, data, materials and methods

Description of study area

The study was conducted in Isingiro district, in South-western Uganda, located approximately between 00°50′S latitude and 30°50′E longitude (Fig. 1). The 2014 Population and Housing Census results estimated the population of Isingiro was 486,360, with 51 per cent of women and 49 percent of men. In 2016, the population was approximately 517,800. The area is situated in the semi-arid 'cattle corridor' – a region synonymous with erratic and extreme climatic conditions, particularly dry spells, and recurrent flooding. Isingiro, like other cattle corridor areas in East Africa, is traditionally known for livestock farming. The district is historically known to have a tropical wet and dry climate, with two rainy seasons (March to May and September to November) and an average annual rainfall of 1200 mm. The temperature ranges from 17 to 30 °C throughout the year [17]. The vegetation is dominated by Savanna grasslands and woodland savannah with forest patches. The district is mainly dependent on agriculture, especially banana production, which accounts for 90 % of the crop area. Other crops grown include beans, coffee, pineapples, and Irish potatoes. Livestock production is an important economic activity in Isingiro district, with cattle and goats being the dominant animals [17]. The livestock sector contributes significantly to food security, income generation, employment creation, and social and cultural values for the households in the district. Animal grazing farms are predominantly located in savannah grasslands that have traditionally provided palatable pasture for the livestock. However, the district faces challenges such as climate change and its associated impacts including water scarcity and inadequate forage resources. Additionally, challenges including poor animal health and breeding services, low value addition and marketing, which affect the livelihoods of the livestock farmers have been extensively reported.

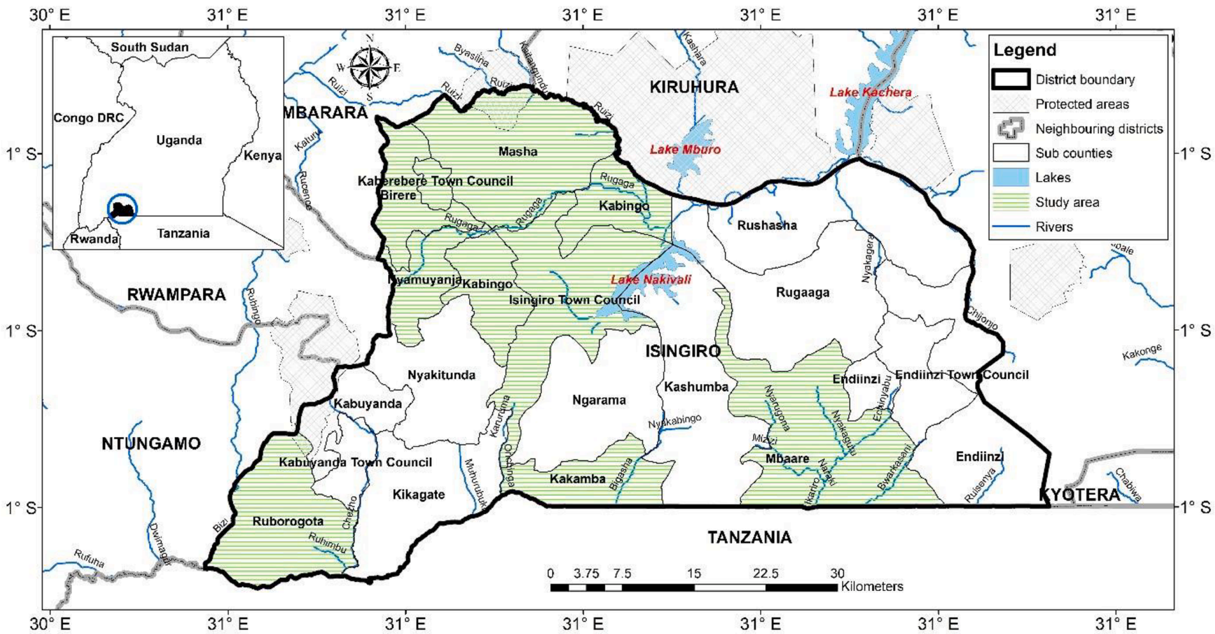

Fig. 1. Study area map showing sub-counties where participants in the survey are located (sampling was undertaken in the shaded areas).

Sampling

We aimed to sample an equal number of male-headed and female-headed households involved in livestock production as a key source of livelihood in Isingiro district, using a snowball sampling methodology [for further information on snowball sampling, see [18]]. This was especially useful for finding female-headed households in a predominantly patriarchal society [19]. The underlying assumption was that households that have both male and female-adult partners living together or a 'non-married' (single) male adult managing the household, are male-headed: while those that only have a female adult managing the affairs of the household are female-headed. The rationale for this is premised on the patriarchal nature of family structures within the region as earlier mentioned. Also, the decision to interview household heads was premised on the assumption that household heads make key decisions regarding livestock production practices at household level [20]. However, finding female-headed households, even while employing the snowball sampling methodology, was challenging. Consequently, our sample had more male-headed households accounting for 76.8 % (92), compared to the 24.2 % (28) that were female-headed, gathered across 8 sub-counties highlighted in Fig. 1. We were not interested in spatially explicit analyses (and for purposes of protecting our study participants, no household GPS coordinates were collected), although we acknowledge that this may be important in the future.

Data analysis

We employed various data analysis techniques. For question 1 (*What are the gender differentiated characteristics, and typologies of households involved in livestock production?)*, principal components and cluster analyses were undertaken. We describe these in turn.

Table 1
Household characteristics.

Variable	Male-headed ($n = 92$)	Female-headed ($n = 28$)	All data ($n = 120$)	Kruskal-Wallis test
Age of HH head*	52.8 ± 2.3	62.0 ± 2.5	54.9 ± 1.9	X^2=20.4, p = 0.00
Marital status of HH head*	Married – 95.7 % Single/Never married – 1.1 % Separated/Divorced – 1.1 % Widower – 2.1 %	Married – 0.0 % Single/Never married – 3.6 % Separated/Divorced – 14.3 % Widow – 82.1 %	Married – 73.3 % Single/Never married – 1.7 % Separated/Divorced – 4.2 % Widow – 20.8 %	X^2=101.1, p = 0.00
Number of biological children	5 ± 1	4 ± 1	5 ± 0	X^2=0.4, p = 0.51
Household-size	6 ± 1	6 ± 1	6 ± 0	X^2=1.3, p = 0.26
Total bi-annual income off-farm	677,209±168,705	417,142±149,535	613,333±133,020	X^2=3.4, p = 0.65
Total land size used for livestock production (in acres)	19.7 ± 7.7	13.9 ± 5.2	18.3 ± 5.9	X^2=0.2, 0.68
Total land size under crop production (in acres)	9.3 ± 7.2	6.5 ± 1.9	8.6 ± 5.4	X^2=0.3, 0.58
Total land size owned (in acres)	29.0 ± 14.5	20.4 ± 7.0	26.9 ± 11.0	X^2=0.1, 0.82
Number of male employees	1 ± 0	1 ± 0	1 ± 0	X^2=2.0, 0.16
Number of female employees*	0 ± 0	1 ± 0	0 ± 0	X^2=19.4, 0.00
Total number of employees*	1 ± 0	2 ± 0	2 ± 0	X^2=13.3, 0.00
Number of cows owned	29±5	28±8	29±4	X^2=0.1, 0.83
Number of goats owned	24±5	21±5	23±4	X^2=0.0, 0.90
Number of sheep owned	15±5	14±5	15±4	X^2=0.4, 0.85
Income from milk sales in the last one year (in UGX)	733,310±183,287	874,800±623,033	769,040±202,214	X^2=0.3, 0.58
Income from cow sales in the last one year (in UGX) *	2026,923±349,734	1217,857±343,383	1855,303±292,943	X^2=4.4, 0.04
Income from manure sales in the last one year (in UGX)	520,000±225,713	235,000±226,764	438,571±175,288	X^2=2.6, 0.10
Total income from livestock production last year (in UGX)	2051,419±378,537	1596,400±711,085	1944,103±330,718	X^2=2.1, 0.15
Annual expenditure on feeds (based on the last one year, in UGX)	985,833±645,811	950,000±1136,360	976,875±494,125	X^2=0.5, 0.50
Annual expenditure on water storage facilities (based on the last one year, in UGX)	316,666±195,394	204,000±188,635	265,454±116,414	X^2=1.3, 0.27
Annual expenditure on forage maintenance (based on the last one year, in UGX	345,161±118,419	261,428±135,338	329,736±98,092	X^2=0.0, 0.86
Annual expenditure on tick control (based on the last one year, in UGX	340,358±131,134	273,035±119,775	322,575±100,717	X^2=0.8, 0.34
Annual expenditure on maintenance of fences (based on last one year, in UGX) *	242,826±167,279	142,583±77,841	208,457±56,368	X^2=5.6, 0.02
Annual expenditure on extension services (based on last one year, in UGX)	234,094±41,268	208,333±107,108	228,574±36,340	X^2=0.7, 0.41
Annual expenditure on workers (based on the last one year, in UGX)	589,015±93,391	609,565±156,300	594,325±78,634	X^2=0.0, 0.88
Total annual expenditure (based on the last one year, in UGX)	1180,675±242,822	1170,000±358,659	1165,035±200,711	X^2=0.20, 0.66
Total daily milk production in the dry season (in litres)	22.0 ± 3.5	24.0 ± 5.6	22.4 ± 3.0	X^2=0.37, 0.55
Total daily milk production in the wet season (in litres)	31.1 ± 5.8	31.9 ± 8.4	31.3 ± 4.8	X^2=0.25, 0.62

Principal component analysis

We conducted an initial exploration of the data: this encompassed the computation of descriptive statistics, focusing on the 'continuous' variables (see Table 1) that were assessed in the questionnaire. The application of the Kolmogorov test revealed that all the variables were non-normally distributed ($p < 0.5$). Having considered variables that characterise livelihood typologies in the study area, the data were subjected to data standardisation to ensure that all the indicators are comparable [21]. The standardisation followed the following general formula;

$$Index\ value = \frac{Actual\ value - Minimum\ value}{Maximum\ value - Minimum\ value}$$

Building on this, the data were screened to eliminate redundant variables using dimensional reduction. This was achieved by using Principal Component Analysis (PCA), a widely used technique to reduce large datasets into smaller data sets without losing much of the original sample data [22]. The technique is used to identify the variables that explain the maximum variability in the data [23]. The equation for the PCA is shown as follows.

Given an I-dimensional variable with mean μ is defined according to Eq. (1)

$$y^t = [x_1, \ldots, x_2] \tag{1}$$

where X = factors, i = ith factor, and y^t is the transpose of y. To find a new set of variables, $Z_1, Z_{2\ldots\ldots\ldots} Z_p$ [whose variance decreases from first to last, each *Zi* (principal components) is taken to be a linear combination of the X_j as in Eq. (2)]

$$z_j = a_{1j}x_1 + a_{2j}x_2 \ldots a_{pj}x_p \tag{2}$$

Where $a_j^t = [a_{1j}, \ldots, a_{2pj}]$

The Kaiser-Meyer-Olkin (KMO) test and Bartlett's test of sphericity were applied to measure the correlation between variables. Variables with a lower communality ($h < 0.475$) were not considered in the PCA because they were not sufficiently correlated with the new factors generated [23]. The factors corresponding to eigenvalues ≥1 were selected to gain a better understanding of the components, as these were more important than the original variables [22]. The regression method was used to estimate factor scores, which were saved as new variables, and used as inputs for the cluster analysis.

Cluster analysis

The components that were retained from the PCA were used to classify households into different clusters using a hierarchical agglomerative cluster analysis [23]. In this study, Ward's cluster algorithm, and squared Euclidean distance measures were used as measures of interval distance between two clusters. This helped to verify the existence of homogenous groups for classification based on the varying propensities.

Ordered probit model

In order to respond to question 2 [How do gender disaggregated household characteristics influence the perceived extent of the effect of water and forage shortage?]—we employed an ordered probit model. But first, we presented descriptive statistics on the perceived impacts of water and forage shortage across male and female-headed households. The probit model enabled us to find out how gender-disaggregated household characteristics influenced the coping patterns of households. According to Williams and Quiroz [24], an Ordered Probit is used when there are more than two outcomes of an ordinal dependent variable. In this study, we asked respondents about the extent of the perceived problem of water and forage shortage due to climate change. Four ordinal categories including limited/low effect, minor effect, significant effect, and critical effect were provided. These were later coded as 0, 1, 2 and 3 respectively. The independent variables included in this analysis were gender (0 = Male, 1 = Female), marital status (0 = Married, 1 = Never married/single, 3 = Separated, 4 = Widow(er)), Education level of household head (0= No education, 1 = Primary, 2 = O'level, 3 = A'level, 4 = Tertiary), and the following continuous variables: Age of household head, household size, total bi-annual income on-farm (from within the farm), total bi-annual income off-farm (from outside the farm), size of land, number of male employees, number of female employees. The equation for the model is as follows;

$$y^* = \alpha' x_i + \varepsilon,\ \varepsilon \sim N(0, 3) \tag{3}$$

$$y^* = \begin{cases} 0\ if\ y^* \le 0 \\ 1\ if\ 0 < y^* \le \mu^1 \\ 2\ if\ 0 < y^* \le \mu^2 \\ 3\ if\ 0 < y^* \le \mu^3 \end{cases}$$

where y^* represents the dependent variable and is the probability that a respondent belongs to at least one category, α' is the coefficient's vector to be estimated; X_i describes the independent variables' vector; ε is normally distributed error term [0, 3], y depicts the observed dependent variable, which indicates the likelihood of the respondent perceiving a higher-level response; and μ describes the cut-off points that signify the inclination. It emphasises the 'natural ordering' among the four groups of the dependent variable of the model.

In order to respond to question 3 [*How do household–level gender disaggregated characteristics influence coping responses to water and forage shortages*], we provide descriptive statistics to show the distribution and characteristics of coping responses to forage and water shortages across male and female-headed households. This was then followed by a Principal Component Analysis (PCA) to identify the major coping practices. The PCA was performed to derive a set of orthogonal principal components (PCs) from the original set of variables representing coping responses and related factors as described earlier. The mathematical equation for PCA is shown in Eq. (1). The scores of the principal components obtained from the PCA were used to create an index representing coping patterns. This was done using the 'predict' command in Stata version 2013 [21]. To explore how gender-disaggregated household characteristics influence coping responses, a Probit model was then employed. The Probit model estimates the probability of an outcome, in this case, the coping capacity index. The gender-disaggregated household characteristics were used as independent variables. The Probit model can be expressed as:

$$P_{(y\ )} = \Phi(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n) \tag{4}$$

Where: *P(y)* is the probability of having a specific coping capacity given the predictor variables, ΦΦ is the cumulative distribution function of the standard normal distribution, $\beta_0\beta_1$, β_2, and β_n are the coefficients associated with the predictor variables X_1, X_2.... *Xn*.

For us to compare gender–based roles in coping with water and forage shortages (question 4) – we present the coping strategies at the gender level and test the differences using a basic, paired T-test, given the relatively small sample sizes.

Results

Gender differentiated characteristics, and typologies of households involved in livestock production

Gender differentiated household characteristics

We start by providing an overview of household-level general characteristics before delving into livelihood typologies. Generally speaking, on average, female heads of households were about 10 years older than their male-head counterparts (X^2=20.4, $p = 0.000$), but they were more likely to be widows or single/never married compared to the male-headed households, the majority (95.7 %) of whom were married (X^2=101.4, $p = 0.000$) (Table 1). In addition, female-headed households had at least one more female employee compared to male-headed households ($p = 0.000$). Male-headed households reportedly earned about UGX 700,000 more on average from the sale of cattle than female-headed households (X^2=4.4, $p = 0.04$, Table 1). Male-headed households spent about UGX 100,000 (approx. USD 27) more on average ($p = 0.02$) on maintaining fences than their female-headed counterparts. There was however no significant difference ($p > 0.05$) between female-headed and male-headed households based on a number of other parameters. For instance, overall male- and female-headed households own 18.3 ± 5.9 ha (mean ± 95 % confidence interval) of land on average, 29±4 cows, 23±4 goats, and 15±4 sheep, although with some variations (Table 1). Estimated general income and expenditures are not dissimilar either, as indicated in Table 1.

Livestock production typologies

Eight (8) principal components with eigenvalues ≥1 were derived from the analysis (selected variables were 28 in total), accounting for 72.4 % of the total variance in the data (Fig. 2a). The largest source of variation in the data was predominantly from the household assets that the farmers owned (PC1). This is followed by these components (in order of importance): on-farm income and expenditure (PC2), seasonal milk yield (PC3), income-education composite (PC4), age household head and number of biological children (PC5), total on-farm income (PC6), number of livestock (PC7), and livestock sales and water storage expenses (PC8) (p = 0.001, KMO=0.72, Supplementary Information 1 (SI: 1)).

The households belong to five typologies (described in Table 2): the largest group (33.9 %) belongs to cluster 2: 'poorest' household category. This is followed by cluster 3 'Moderate income households with largest household sizes but lowest daily milk production' and cluster 1: 'Low-income households with highest daily milk production' accounting for 28.6 % and 27.7 % respectively. Clusters 4: 'Moderate income households with 'middling' characteristics' and 5 'richest households' have the least number of members accounting for 6.3 % and 3.6 % respectively (Fig. 2b). Interestingly, none of the female-headed households belong to Cluster 5 (richest household) typology, but the majority belong to Cluster 2 (poorest household) typology (Fig. 2c). The picture is more mixed for male-headed households although clusters 1, 2 and 3 dominate.

Influence of gender differentiated household characteristics on the perceived extent of the effect of water and forage shortage

Perceived effect of water and forage shortage

Male- and female-headed households reported high expenditures on management of livestock diseases, reduced milk production, community conflicts as the most important climate-related effects of forage and water shortage - we find no significant differences in perceptions between the male-headed and female-headed households ($p > 0.05$) on how the effect of forage and water shortage affects their livestock production (SI: 2). In other words, it does not matter what the gender of the household head is, both the male- and female-headed households reported similar effects of water and forage shortage.

Perceived extent of the water, and forage shortage due to climate change

Water and forage shortage were mostly perceived as "significant" and "critical" accounting for 25 % and 19.2 % of the total responses respectively (SI: 3). There was no significant gender-based difference ($p > 0.05$) in these views, based on male-headed and

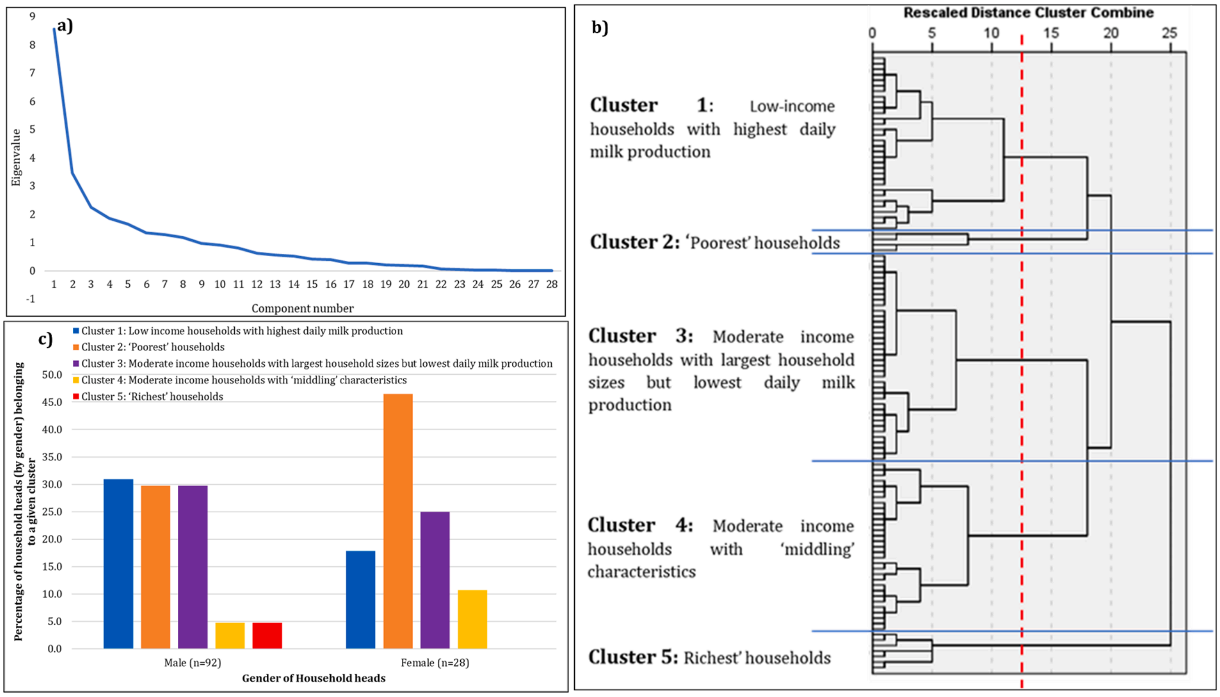

Fig. 2. Household clustering: **a)** scree plot showing the contribution of each PC to the total variation in the dataset; **b)** Dendrogram showing livestock farmer clusters, **c)** Gendered household typologies.

Table 2
Summary of cluster characteristics (mean ± 95 %CI).

Cluster	Summary of peculiar characteristics	Cluster classification/naming
1	Lowest age (51.3 ± 3.7), moderate household size (6.2 ± 0.8), relatively low on-farm income (432,258±98,004), relatively small total land sizes (16.6 ± 4.2), lowest number of employees (0.8 ± 0.3), highest daily milk production (35.5 ± 5.3), relatively low on-farm income from livestock production (1274,032±407,016), relatively low total on-farm expenditure (815,322±331,273)	Low-income households with the highest daily milk production
2	Highest age (59.5 ± 3.2), smallest household size (4.1 ± 0.5), lowest on-farm income (323,684±180,480), smallest total land size (14.1 ± 3.1), relatively low number of employees (1.4 ± 0.4), relatively low daily milk production (15.5 ± 3.2), lowest income from livestock production (1250,000±481,865), lowest total on-farm annual expenditure (705,354±149,332)	'Poorest' households with the lowest incomes and expenditures on-farm and smallest land sizes
3	Middling age (53.3 ± 3.1), largest household size (8.1 ± 0.8), relatively high on-farm income (827,187±224,078), relatively large total land sizes (30.9 ± 8.2), moderate number of employees (2.0 ± 0.4), lowest milk production (13.0 ± 4.0), moderate income from livestock production (2218,437±772,427), moderate total on-farm expenditure (1172,687 ±282,317)	Moderate income households with the largest household sizes but lowest daily milk production
4	Middling age (57.7 ± 11.1), moderate household size (5.6 ± 2.2), moderate on-farm income (667,142±558,101), moderate total land sizes (26.7 ± 14.9), moderate number of employees (2.6 ± 1.0), moderate daily milk production (15.0 ± 5.4), moderate income from livestock production (2884,285±1389,936), relatively high total on-farm expenditure (1952,857±1114,119)	Moderate income households with 'middling' characteristics
5	Middling age (56.0 ± 9.0), moderate household size (6.0 ± 4.1), highest on-farm income (907,500±887,229), largest total land size (44.0 ± 15.8), largest number of employees (4 ± 2), moderate daily milk production (16.8 ± 9.9), highest income from livestock production (4025,000±2152,077), highest total on-farm annual expenditure (4262,500±1419,337)	'Richest' households with the highest incomes and expenditures on-farm and largest land sizes

female-headed households (SI: 3).

Influence of household characteristics on the perceived extent of the effect of water and forage shortage

Female-headed households categorized as divorced or separated exhibited a higher likelihood of experiencing the effects of forage shortage (coefficient = −2.74, $p = 0.047$). The effects of forage shortage are those already highlighted in 3.2.1. On the contrary, an increased presence of male workers within female-headed households was linked to a reduction in vulnerability to the perceived effects resulting from forage shortage due to climate change (coefficient = 1.28, $p = 0.002$). However, there was no statistically significant influence on vulnerability in relation to water shortage ($p > 0.05$) (Table 3).

Influence of gender disaggregated household–level characteristics on coping responses to water and forage shortages

Coping responses to the effects of water and forage shortage

Reducing herd size, fodder conservation and growing fodder crops were reported as the most dominant ways in which livestock farmers coped with water and forage shortages induced by climate variability, and there are no gender differences in these dominant coping strategies ($P > 0.05$; SI: 4). Male-headed households were more likely to shift animals to another grazing area compared to their female-headed counterparts ($p = 0.04$).

Influence of gender disaggregated household characteristics on coping responses with water and forage shortages

Among female-headed households, an increase in household size and on-farm income significantly and positively correlated with an increase in coping capacity[2] in the context of forage scarcity ($p < 0.05$). However, in both male- and female-headed households, a reduction in off-farm income resulted in a statistically significant relationship with an increase in coping capacity ($p < 0.05$). In the context of water scarcity, among female-headed households, there is a positive relationship with increase in male employees ($p < 0.05$). This suggests that the engagement of male labour within female-headed households contributes positively to their adaptive strategies in managing water shortages. For all respondents, attaining advanced education was associated with an increase in copying capacity to water shortage ($p < 0.05$) (Table 4).

Gender-based roles in coping with water and forage shortage – based on employees on the farm

A gender dimension is explicit in the roles male and female employees play in both male- and female-headed households in coping with water and forage shortages. There is a significant difference ($p < 0.05$) between livestock production-related roles allocated to male and female employees on-farm. The majority of the roles can be described as 'masculine' as they were dominated by male employees. Notable examples of such roles include provisioning forage, milking cows, taking animals to water, and monitoring the health of animals. More 'female' roles were observed in male-headed households than female-headed households - for instance, we see women providing forage in both male- and female-headed households but women were reported to be taking animals to water, maintaining animal health, keeping farm records, maintaining water supply systems, and milking in male-headed households, which were missing in female-headed households. However, their percentages were low (Table 5). In female-headed households, almost all the roles were undertaken by male employees (Table 5).

Discussion

Gender differentiated characteristics, typologies and roles of households involved in livestock production

Evidence from this study shows that male household heads were generally younger than their female counterparts. Most of the female heads were widows or divorced. This confirms UBOS [25] findings where 59 % of women 60^{+}years were widowed. The finding is an indication that men were more likely to be involved in decision making at an earlier age than women who became household head at an older age often after the death of, or separation from, their husbands. These findings relate to other studies which show that in traditional African communities, women gain agency and voice with age, when they acquire more respect and freedom [26,2]. The findings further reflect a patriarchal social structure among pastoralists where men dominate most of the cattle–related decision making and responsibilities.

This study also shows that female-headed households needed additional female employees for the provision of forage in livestock production compared to their male-headed counterparts. Involvement of women in traditionally male roles could be an indicator of change in legitimised social and cultural norms [8,27]. This further points to the fact that gender constructions of what is deemed appropriate or inappropriate for women or men is diverse and can change overtime to reflect the realities in society [8], as exemplified in this study in Isingiro District. As a caveat, we argue that our study is cross-sectional in nature - and our results do not necessarily demonstrate changing gender roles through time. Our assertion of 'change' is premised on our experience and knowledge of the family structures in the region (in particular the last two authors have over 4 decades of research experience in this field combined). However, male-headed households earned more from the sale of farm products, particularly the sale of cattle than female-headed households, despite female-headed households having more employees. The inequality in income (see Table 2) is possibly due to more market information access by men than women. Most women in the area are less likely to travel from their homesteads compared to men due to interlinked factors such as cultural beliefs and responsibilities around household activities. This constraint many female farmers

[2] Coping capacity is not quantitatively measured in this study per se, however, we rely on perceptions of male- and female-heads of HHs to evaluate their ability to manage effects of climate-induced water and forage scarcity on their livestock enterprises. The capacities could be quantitatively determined through the strategies they employ but we acknowledge that this was beyond the scope of our study, we therefore heavily rely on farmer perceptions of their capabilities (to cope).

Table 3
Results of ordered Probit model for the factors that influence the extent of farmer perceptions on forage and water shortage.

	Forage shortage		Water shortage	
	Coef.	*P* > z	Coef.	*P* > z
Gender (RC= Male)				
Female	−0.58	0.26	−0.62	0.092
Age of HH	0.04	0.093	0.01	0.377
Household size	−0.11	0.244	0.06	0.375
Marital Status (RC = Married)				
Single/Never married	−0.96	0.454	−6.20	0.986
Separated/Divorced*	−2.74	0.047	0.13	0.859
Widow(er)	−0.07	0.880	−0.09	0.787
Education of household head (RC = No education)				
Primary	0.15	0.765	0.66	0.095
O'level	−0.12	0.852	0.58	0.183
A'level	8.09	0.979	6.80	0.985
Tertiary	−1.37	0.098	0.77	0.192
Total bi-annual income on-farm	0.00	0.936	0.00	0.195
Total bi-annual income off-farm	0.00	0.131	0.00	0.460
Size of land	−0.01	0.344	−0.01	0.118
Number of male employees*	1.28	0.002	0.37	0.115
Number of female employees	−0.75	0.058	0.14	0.612
/cut1	−1.01		0.608	
/cut2	0.8		2.341	
/cut3	2.81			

Table 4
Household level gender-disaggregated determinants of coping capacity in male and female-headed households.

Coping Capacity Index	Forage shortage			Water shortage		
	Male Headed HH	Female headed HH	All	Male Headed HH	Female headed HH	All
Age of HH	−1.E-02	5.E-02	−1.E-02	−1.E-02	−1.E-02	−6.E-03
Marital Status (RC = Married)						
Single/Never married	−1.E-01		−3.E-01	−4.E-01		−4.E-01
Separated/Divorced	−9.E-02		−6.E-01	−4.E-01		−3.E-01
Widow(er)	4.E-01	−2.E-01	−4.E-01	3.E-01	−7.E-01	2.E-01
Education of HH (RC = No education)						
Primary	3.E-01	1.E-01	−1.E-01	5.E-01	−1.E-02	4.E-01
Ordinary level	6.E-02	−9.E-01	−7.E-01	4.E-01	−2.E-01	1.E-01
Advanced level		2.E+00	7.E-01		3.E+00	2.E+00*
Tertiary Level	5.E-01		2.E-01	5.E-01		4.E-01
HH size	6.E-02	3.E-01*	5.E-02	2.E-02	2.E-02	4.E-02
Total bi-annual income on-farm	3.E-08	2.E-06*	−3.E-07	−8.E-08	1.E-07	−5.E-08
Total bi-annual income off-farm	−4.E-07*	−2.E-06*	−8.E-08	−1.E-07	8.E-07	−1.E-07
Size of land	−2.E-03	−1.E-02	−3.E-03	3.E-03	−1.E-02	−2.E-03
Number of male employees	3.E-01	3.E-02	1.E-01	6.E-02	1.E+00*	3.E-01
Number of female employees	2.E-01	−6.E-01	9.E-01	9.E-01	6.E-01	5.E-02
_cons	−6.E-02	−4.E+00	8.E-01	9.E-01	9.E-01	−1.E-01
Number of observations	87	26	116	90	26	116
F	2.37	19.97	1.380	0.51	1.72	1.05
Prob > F	0.0122	0.000	0.180	0.9127	0.1693	0.4151
R-squared	0.2774	0.9485	0.150	0.08	0.5743	0.1267
Adj R-squared	0.1602	0.901	0.042	−0.0773	0.2398	0.0056
Root MSE	0.85642	0.40918	1.183	0.97357	0.96416	0.9736

from engaging in public gatherings and exchanges where most of the information, including on market access, is mainly obtained [28, 29]. Livestock production in Isingiro district is a male-dominated enterprise with highly defined patriarchal systems. The findings concur with [30], who showed disproportionate control of the majority of livestock related benefits by men in livestock production areas in Uganda.

This study revealed that women were more involved in managing small value livestock e.g., subsistence chicken, goats, or pigs, while higher value cattle management roles were predominantly assigned to men. Male-headed households were more likely to own more animals (especially cattle) and cope better with climate-induced water and forage shortage. A study conducted in Zimbabwe by Ndlovu & Mjimba [2] reported similar findings – that livestock production is male dominated. Although women play important roles in livestock production; their roles are undervalued, underestimated or ignored by both researchers and policy makers [31–33], but fact remains that men still dominate farming and livestock-related markets in rural areas across Africa.

Table 5
Gender-based roles in coping with water and forage shortage on the farm.

Roles in coping with forage and water shortage	Male-headed ($n = 92$)		Female-headed ($n = 28$)		All ($n = 120$)		Paired t-test
	Male	Female	Male	Female	Male	Female	
Providing forage	75.0 %	7.6 %	82.0 %	17.9 %	76.7 %	10.0 %	$t = 15.3, p = 0.00$
Taking animals to water	50.0 %	1.1 %	43.0 %	0.0 %	48.3 %	0.8 %	$t = 9.8, p = 0.00$
Maintaining animal health	46.7 %	2.2 %	32.1 %	0.0 %	43.3 %	1.7 %	$t = 9.2, p = 0.00$
Keeping farm records	22.8 %	2.2 %	21.4 %	0.0 %	22.5 %	1.7 %	$t = 5.3, p = 0.00$
Selecting, training and supervising staff	4.3 %	0.0 %	0.0 %	0.0 %	3.3 %	0.0 %	$t = 2.1, p = 0.01$
Maintaining water supply systems	52.2 %	2.2 %	39.3 %	0.0 %	49.2 %	1.7 %	$t = 9.8, p = 0.00$
Maintaining fences, sheds, shelters	27.2 %	1.1 %	39.3 %	0.0 %	30.0 %	0.8 %	$t = 6.7, p = 0.00$
Marketing on-farm produce	2.2 %	0.0 %	0.0 %	0.0 %	1.7 %	0.0 %	$t = 1.4, p = 0.16$
Milking cows	69.6 %	1.1 %	89.3 %	0.0 %	74.2 %	0.8 %	$t = 17.5\ p = 0.00$
Organising sales, transport of animals	0.0 %	0.0 %	3.5 %	0.0 %	0.8 %	0.0 %	$t = 1.0, p = 0.32$

Contrary to most studies, there was no significant difference in asset ownership characteristics including land, livestock, and financial assets between female-headed and male-headed households. This is surprising considering the limited access and ownership of productive assets that have characterised women in most parts of Africa (e.g., [31,2,34,7]). However, the findings in Isingiro district point to the fact that 82 % of the female-headed households were widows who may have inherited their husbands' productive assets. Related studies have attributed increased ownership of assets, such as land, to location specific cultural history and social norms in areas where marriage is common among close relatives in the same community [35]. There is a related history and tradition in the region where this study was conducted, but this is less likely to be the actual explanation because of the high number of recent immigrants from different cultural backgrounds. Most of the migrants are from Kigezi region of south-western Uganda. Other immigrants are from Rwanda, Burundi and Democratic Republic of Congo who came as refugees. The district has a very big refugee settlement [36]. It is, therefore, not clear what explains this unique state of affairs on similar levels of asset ownership between men and women, and therefore further research is required.

Gender roles in livestock production included categories that were dominated by men. These roles included grazing animals that involves movements for long distances from homes, and other physically demanding activities, such as treating animals [this is a very manual task that may involve restraining the animal, and administering medication injected through the animal's thick skin]. Similar findings were reported in a previous study conducted in Kiruhura and Isingiro districts. The study showed that unlike in Isingiro district, Kiruhura district had both men and women who had migrated in search of water and forage [27]. This finding points to the limited mobility of the female-headed households in Isingiro District due their age (60+). Moreover, women-headed households were less likely to benefit from help their male partners would have provided in a marriage setting, since most of them were widows or divorced compared to the male-headed households, the majority of whom were married. This illustrates potentially higher-level susceptibility of female-headed households to water and forage shortage in these communities, particularly female-headed households that lack capacity to engage a male employee. A study by Van Aelst and Holvoet [37] noted that a woman's position within the adaptation typology depends more on her marital status. A married man's adaptation position does not typically worsen when he leaves the marriage. Family ties (based on marriage) can enhance the ability for social organisation and networks to enable cooperation to cope with the effects of shocks and stresses [38]. Absence of such cohesion and bonds could inhibit or lead to loss of collective action needed to adjust to water and forage shortage. Marital status affects the social capital of a community, in turn impacting on their adaptive capacity prospects[9]. This is particularly more so for women partly because of their dependence on men to undertake roles perceived and socially constructed to be 'masculine' in livestock production, as shown by the results of this study. This agrees with other studies that have reported interactions between climate-related stresses and shocks and socio-cultural norms and values, which shape household gender relations that result in culturally constructed vulnerability reduction roles (e.g., [6,26]).

Influence of household gender differentiated characteristics on perceived effect of water and forage shortage

Unlike most of the existing literature on the influence of gender on risk and impact perception, this study shows that there were no significant differences in perceived extent of the problem of water and forage shortage on livestock production. The results show that the effect of water and forage shortage is generally well recognised in this particular area regardless of one's gender. The findings can be attributed to the high level of awareness, including through lived experiences, about drought and dry spells across this particular area [39]. In our previous study, we established that all farmers perceived drought as a problem for food security, with about 96 % indicating that they had observed changes in drought patterns in the previous 15 years in the area, while about 97 % believed that drought had steadily increased in intensity and frequency of occurrence (*ibid*). Nonetheless, impact risk perception variation is influenced by a myriad of factors including socio-political, demographic, value systems and worldviews [40]. Therefore, awareness levels may not necessarily be the only explanation as to why there was a similar perception of drought problem including its effect on water and forage in both male- and female-headed households. This calls for further investigation. The status of affairs presents a potential fertile ground for engaging farmers on policy and practice for climate change adaptation and mitigation.

The results of this study show that marital status and number of male employees were the most important factors for perceived extent of water and forage shortage caused by climate variability and change. Household heads that were categorized as divorced or separated exhibited a higher perception of vulnerability to water and forage shortage. This is in line with other studies (e.g., [41]) that have reported marital status as an important factor for the level of perceived effect and risk of climate hazards. A study by Atube et al. [42] revealed a significant influence of marital status of the household head on drought perception and adaptation response. Female-headed divorced/separated households have been indicated, to be more likely to face challenges in coping with water and forage shortages due to human and financial resource barriers, as well as lower social capital [42].

Our data show that the higher the number of male employees, the less the perceived extent of the effect of water and forage shortages. One meaning, in the broader context of this study, is that more male employees are more likely to lessen the labour burden to address water and forage scarcity, and hence the less extent the perceived extent of the effect of water and forage shortages, compared to those with less (or no) labour force. The influence of number of male workers on perceived effects of drought and associated water and forage shortage is well aligned to the typical association of livestock farming activities and roles with men in the area. In the SW Uganda region where the study was conducted, women have traditionally been considered to do domestic supportive roles for men as they undertook livestock farming activities. This is part and parcel of the traditional attachment of masculinity and femininity to livestock farming, as was discussed earlier [26].

Determinants of coping response to water and forage shortages

The most important factors for coping with water and forage shortage, from this study, were household size (female headed) and income (for both male- and female- headed households). Particularly, among female-headed households, increase in household size increased coping capacity in the context of forage scarcity. During dry spells and droughts, sustaining livestock production amidst water and forage constraints is labour intensive. Bigger household sizes guarantee the much-needed labour to cope with the effects of drought on livestock production. More household members can help with taking on the varied tasks such as looking for water, grazing animals, and searching for alternative sources of forage. The finding on household size being an important determinant of coping with drought in female-headed households (Table 3) suggests that having more individuals in a household helps in bridging gaps that might be associated with absence of labour from men, especially for widows and unmarried women. That way, physical limitations and 'negative' social constructs associated with women can be compensated for [43]. Studies in the same geographic context have reported similar findings (e.g., [44]). In that study, it was reported that households with bigger membership sizes were more likely to adopt rainwater harvesting technologies to respond to drought than those with a smaller household size. Moreover, within the study area, most of the household labour is predominantly provided by family members [39]. Therefore, household size can be looked at as a safety net for labour availability and livelihood capacity to respond to the impacts of drought on livestock farming [45]. But in some instances, larger household sizes may not necessarily translate into more available labour for agricultural production, as some household members may have other obligations or preferences [46].

Furthermore, our data show that household income level is another key determinant for drought coping strategies, especially, for female-headed households. Income can enable or inhibit the ability to meet the required inputs for livestock production including labour costs [47]. Farmers with higher incomes are more likely to apply drought coping strategies including those that enable them to meet forage and water needs, such as rainwater harvesting, compared to those with lower incomes [39]. Female-headed households are more likely to find it difficult to cope with drought effects due to, relatively, lower household income. Such income deficiencies in a household or community may cause failure to meet investment needs for rainwater harvesting and storage during rainy seasons, hence shortages during dry spells and droughts. When coupled with the cultural norms and perceived limitations such as inability to migrate cattle to new areas with forage and water, income deficiency constrains adaptation for women.

Gender-based roles in coping with water and forage shortage

The results also revealed complementary roles between men and women in livestock production, with more female roles observed in male-headed households than female-headed households (refer to Table 5 in the results section). This shows that men needed female employees more than women. On one hand, this finding, further, underscores the traditional division of labour between men and women, where men tend to focus on their normative livestock production responsibilities and roles in livestock keeping, and hire female employees to undertake activities socially defined for women. On the other hand, there is a growing shift and diversification of gender roles and ways of being among livestock dependent communities, in Uganda (see our caveat in Section `Gender differentiated characteristics, typologies and roles of households involved in livestock production'). For instance, in their study, [48] report women who have disrupted gendered social norms and expectations in livestock management within their household and community. The case of women's participation in the act of milking is an example where women have challenged social norms and beliefs about traditional work roles, within agriculture, that were traditionally meant for men. The shift is partly driven by the value attached to involvement in and ownership of livestock. Livestock, especially cattle, are among the most valuable assets of a rural household in Uganda, which have been demonstrated to help women in accumulating other assets, such as land, housing, or more livestock, thereby increasing individual and household financial security and wealth (*ibid*).

Conclusions

Our study sought to assess livestock farmers' response to drought-induced forage and water scarcity with a case study from South-western Uganda. We ask whether a gendered approach is useful when thinking about (policy and practice) interventions. To achieve this, we categorised surveyed farmers into livelihood typologies, and interrogated their perceptions on drought-induced vulnerability, and assessed their coping strategies from a gendered lens. The assumption was that by identifying male-headed and female-headed households involved in livestock production as a main means of livelihood, we would be able to obtain gender disaggregated data based on decisions made by the household heads. We argue that this was successful. However, it was more difficult to find female-headed households because of the patriarchal nature of the (South Western) Uganda from which the sample was drawn. Unsurprisingly, our data show that livestock (focusing on cattle) production is a predominantly male-dominated activity – with more male-headed households likely to own more animals, engage in 'manual' labour operations, and therefore cope better with climate-induced water and forage shortage. Female-headed households were more likely to have more male employees to manage the traditionally constructed 'male' roles in livestock husbandry. But they were more disadvantaged by lower income (reported), and therefore faced a more difficult task to cope with drought-induced water and forage scarcity: male-headed households had a better coping capacity to water and forage shortage than female-headed households. We, however, find that some traditional gender roles in livestock management are changing, notably milking of cows, provisioning of forage, milking cows, taking animals to water, and monitoring the health of animals. We, therefore, note that gendered constructions are not permanent but keep changing according to the contextual reality, though the changes were not drastic in the study area. It is crucial to use a gender lens in addressing the effects of climate change hazards, such as drought, to ensure gender and social inclusion in adaptation interventions. It is also important to empower female-headed households to get fully involved in livestock production for enhanced lives and livelihoods. Potential areas for enhancing adaptive capacity include strengthening capabilities to use available resources by women, and inclusive decision making (although this was beyond the scope of our investigation). This has implications for adaptation policy, and interventions should take into consideration the associated household-level gender dynamics within the local context, and more broadly in Sub-Saharan Africa with similar characteristics.

Data availability statement

The authors are open to sharing the data used in this study with parties, upon request to support further research in this field.

CREDIT author statement

David Mfitumukiza: Conceptualization, Validation, Investigation, Resources, Writing – Original Draft, Writing – Review & Editing, Supervision, Project administration, Funding acquisition **Ronald Twongyirwe:** Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Data Curation, Writing – Review & Editing, Visualization, Supervision **Gordon Y. Mwesigwa:** Methodology, Software, Validation, Formal analysis, Data Curation, Visualization Writing – Review & Editing **Esther Kebirungi:** Software, Formal analysis, Investigation **Viola Nilah Nyakato:** Validation, Writing – Review & Editing, **Consolata Kabonesa:** Validation, Writing - Review & Editing

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Conflicts of Interest

The authors declare no conflict of interest.

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