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Dominant practices, information, and constraints of soil moisture conservation and nutrient management for range pastures in a sedentary grazing system in South-Western Uganda

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Range pastures constitute the major source of livestock feeds throughout the year in the grazing areas of Uganda. However, pasture yields have been declining overtime, yet there is limited information on efforts of improving pasture productivity through soil moisture conservation and nutrient management. This study assessed soil moisture conservation and nutrient management practices used by livestock farmers, sources of information, and constraints hindering adoption of the potential practices in range pasture management. Through simple random sampling, semi-structured questionnaires were administered to 250 livestock farmers in five districts in South-western Uganda. Agroforestry was the dominant soil moisture conservation and nutrient management practice used in the range pastures (87.6%). Farmers' own knowledge was the major source of information (49.1%) while lack of information (67.2%) and lack of funds (61.1%) were the major constraints for farmers' adoption of soil moisture conservation and nutrient management practices. Therefore, this study recommends farmer participatory testing and adaptation of alternative practices alongside agroforestry, inclusion of soil moisture conservation and nutrient management practices for range pastures in extension programs for livestock production and financial incentives to livestock farmers to boost their capacity to invest in soil management practices for sustainable production of range pastures.

Key words: Agroforestry, farmers' knowledge, range pastures, soil management, sedentary pastoralism.

INTRODUCTION

Range pastures comprising of naturally growing grasses and legumes constitute the major source of feeds throughout the year for livestock production in South-western Uganda (Katuromunda et al., 2017). For decades, livestock grazing in the sub-region was characterized by nomadism where the higher mobility of

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herds and more wide spread pasture resting enabled recovery of the range pasture (Gantuya et al., 2021). This created an adequate and sustainable source of livestock feeds. However, following changes in land use as a result of population explosion, sedentary pastoralism which involves grazing of animals in a confined area and on a permanent basis has taken over the traditional nomadic pastoralism (Muwanika et al., 2019). In the sedentary grazing system, lack of adequate pastures is the major constraint of livestock production for pastoralists in South-western Uganda (de Vries, 2019). This is largely attri-=buted to climate change effects mainly drought, inappropriate land use practices and exceeding livestock carrying capacities (Kabonesa and Kindi, 2013; Byenkya et al., 2014).

For instance, due to climate change effects, it has become common for South-western Uganda to experience drought for at least 183 days a year (Ntakyo et al., 2020), which negatively affects the productivity of range pastures. More so, whereas optimum stocking rate of livestock in semi-arid areas is recommended at 0.71 Tropical livestock Unit/Ha (TLU/Ha), (Mulindwa et al., 2009), the average stocking rate of farms in grazing areas of South-western Uganda stands at 1.4 TLU/Ha (Tibezinda et al., 2016). Such a high stocking rate exerts pressure on the available feed resources thus affecting the productivity of livestock which is reflected in low milk yields and high livestock mortalities especially in the dry season.

The decline in range pasture productivity poses diverse negative consequences to the socio-economic well-being of livestock farmers in South-western Uganda. Over 60% of the households in the grazing areas of South-western Uganda depend on livestock production as a source of livelihood (Makuma-Massa et al., 2017). At a national level, over 37 % of the cattle products especially milk that contribute to the country's Gross Domestic Product are obtained from South-western Uganda (Creemers and Aranguiz, 2019). Thus, there is need for interventions that are capable of improving the productivity of range pastures in the sub-region for sustainable livestock production.

Like all agricultural systems, the status of soil moisture and nutrients is of paramount value in sustainable production of range pastures (Zornoza et al., 2015). These soil parameters influence rates of pasture growth and regeneration following grazing which aspects are pivotal in livestock production. In most grazing areas, soil moisture and nutrients are highly affected by bare grounds and compacted soils (Bolo et al., 2019). Such conditions are conspicuously evident in the grazing areas of South-western Uganda (Njagi et al., 2022), calling for strategies to counteract the pasture production challenges.

In developed countries, there is increasing literature highlighting interventions that improve the productivity of range pastures (Aguiar et al., 2017; Zu Ermgassen et al., 2018; Griffiths et al., 2021). For instance, in New Zealand, range pastures have been intensively managed through increased nitrogen fertilizer application and irrigation (Whitehead et al., 2018). In sub-Saharan Africa, information on pasture improvement practices focusing on soil moisture conservation and nutrient management is largely lacking. For South-western Uganda, it is reported that in the last decade, there were efforts of improving the productivity of range pastures through the dryland husbandry project. The project promoted practices which included pasture establishment; organic manuring, water harvesting, over-sowing and reseeding; legume pasture seed production and erosion control (Twinamasiko et al., 2020). Without clear explanation, there was unanticipated drop out of implementation of pasture improvement practices and technologies by livestock farmers upon the project expiry.

Thus, refocusing pasture improvement practices through soil moisture conservation and nutrient management is needed especially in the face of climate change where production resilient technologies are desired. However, baseline information on existing practices which is necessary in determining pathways for sustainable management of the range pastures remains scanty. Therefore, this study sought to assess: (1) What soil moisture conservation and nutrient management practices are being undertaken by farmers in range pasture management? and (2) What information sources and constraints of soil moisture conservation and nutrient management regarding range pasture management are being utilized and experienced by the livestock farmers?

THEORETICAL FRAMEWORK

In several farming communities, adoption of agricultural innovations is reported to be a function of extrinsic factors such as the characteristics of the adopter and intrinsic factors especially the knowledge, perceptions and attitudes of the potential adopter towards the innovation (Meijer et al., 2015). The external environment for instance social networks, extension systems, policy support and market opportunities at the exposure of the adopter during decision making have equally impacted on farmers' response to technologies (Oriana et al., 2019). Depending on the predominant context, a range of factors can positively or negatively impact on farmers' ability to adopt technologies (Onuche et al., 2020).

Understanding how different aspects impact on farmers' decision regarding production enhancing technologies is pivotal in designing effective technological packages and dissemination mechanisms. As presented in Figure 1, this study focused on highlighting the different soil moisture conservation and nutrient management practices in the range pastures in South-western Uganda, sources of information and constraints and underlying factors that shaped the response of

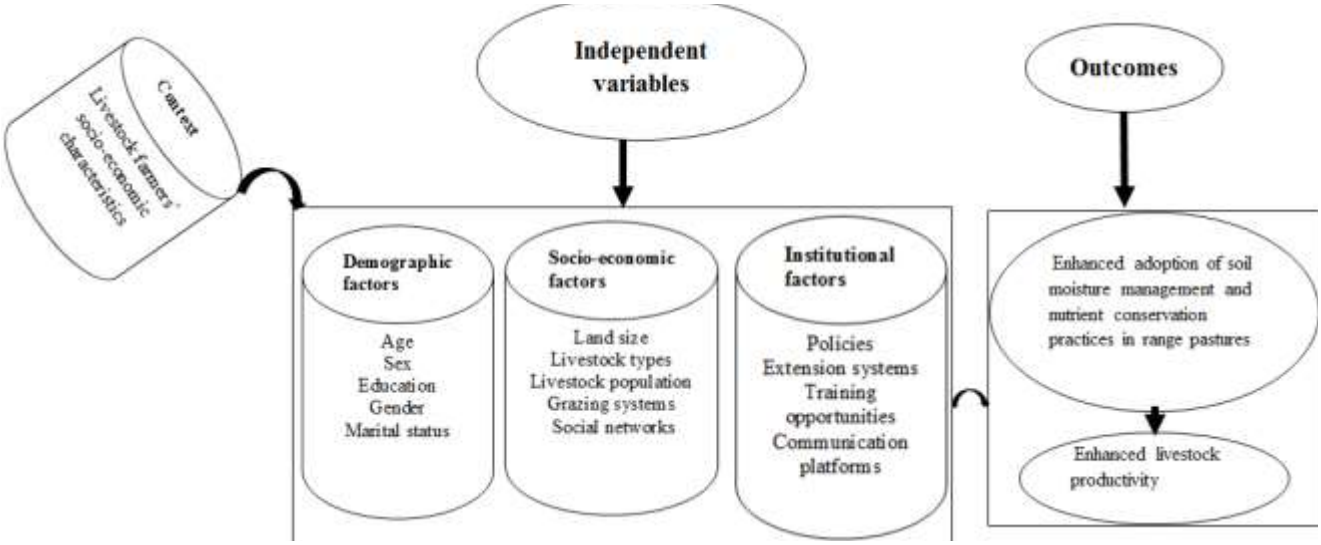

Figure 1. Theoretical framework of the study.
Source: Author's Survey

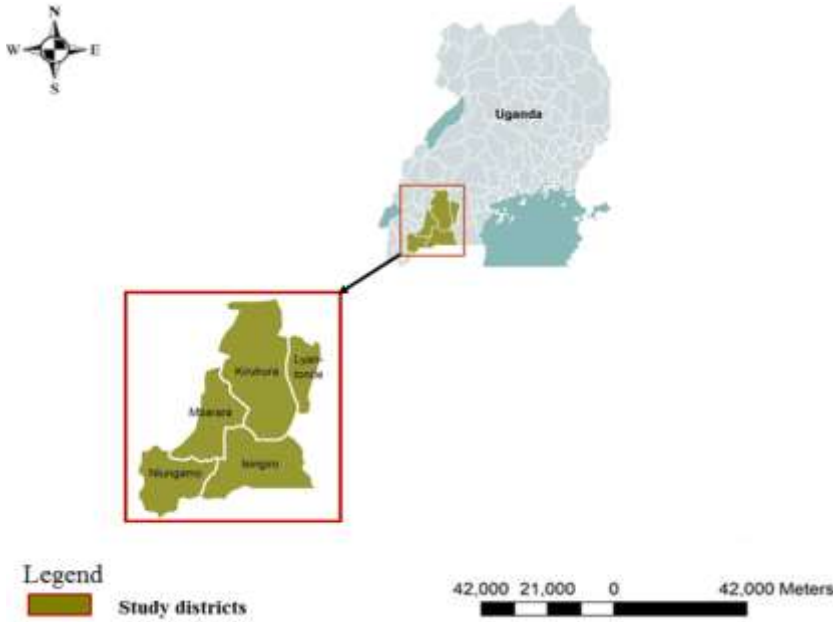

Figure 2. Map of the study area.
Source: Author's survey using a computer program

farmers to the different soil management aspects.

METHODOLOGY

Description of the study area

This study was carried out in five districts namely; Isingiro, Kiruhura, Lyantonde, Mbarara and Ntungamo (Figure 2). The study districts are located in the southern part of the cattle corridor of Uganda and constitute the livestock hub of the country (Balikowa, 2011; Sempiira et al., 2017). The climate is predominantly semi-arid with mean annual rainfall of 1010 mm distributed in a bimodal pattern (Owoyesigire et al., 2016). Temperature ranges from 20 - 30°C where high peaks are recorded in January and July and the average elevation of the area stands at 1800 m above sea level (Twongyirwe et al., 2019). Soils are generally sandy loam and basing on the nature of climate and soils, savannah grassland type of vegetation with scattered Acacia tree species characterize the area. Livestock production is the major economic activity where

dominant domestic fauna is cattle comprising of the indigenous Ankole long horn cattle and Ankole Longhorn X Holstein Friesian crosses (Johansson et al., 2015).

Study design and data collection

Using purposive sampling techniques, two livestock dominated sub-counties in each of the study districts were selected. This was done with the help of the District Production Officers. In each sub-county, 25 livestock farmers (50 per district) were randomly selected using simple random sampling techniques. In the latter method, key community roads/access routes connecting the livestock farmers in the area were identified with the help of Sub-county extension officers. Along each route, a sample homestead was selected on opposite sides of the road at an interval of two farm homesteads from the preceding house. Within a homestead, the respondent considered was the household head, wife or a responsible mature person who had been involved in the day to day running of the farm activities for a minimum period of 5 years. A semi-structured questionnaire was administered to a total of 250 respondents. Data were collected on selected socio-economic profiles of respondents, land and grazing characteristics, soil moisture conservation and nutrient management practices used in the range pastures, sources of information and constraints experienced by farmers regarding soil moisture conservation and nutrient management in the range pastures.

Data analysis

The collected data were coded and entered into SPSS version 16.0 statistical software for descriptive and inferential statistics. Frequency tables and charts were generated using descriptive statistical tools to present information summaries of the households. Non-parametric test in form of Chi-square was undertaken to establish significant associations between the dependent and independent variables. The dependent variables in the study included soil moisture conservation and nutrient management practices, sources of information for the practices and constraints experienced by farmers in adoption of diversified practices. Independent variables included age, gender, education level, marital status, land and grazing characteristics and grazing systems of the respondents. Due to the multiple choice nature of sources of information and constraints experienced by farmers, multiple response sets were created and associated frequency tables generated. The major responses from multiple response tables were subjected to Multivariate regression analysis to identify significant associations with the independent variables. The choice of multivariate analysis was based on the strength of the test to establish associations between multiple dependent variables and independent variables in a single analysis. Where significant associations existed, cross tabulation tables were generated to display the extent to which categories of independent variables influenced the dependent variables.

RESULTS AND DISCUSSION

Socio-demographic characteristics of the respondents

In this study, a large number of the respondents were male (62.0%, n=155) and the dominant age range was 51-60 years (29.6%, n=74) (Table 1). For most of the respondents, primary status was the highest level of education attained (31.6%, n=79) and 87.2% (n=218) of the respondents were married.

Household grazing characteristics of the respondents

Table 2 shows that the majority (31.2%, n=78) of the respondents owned up to 20 acres of land, where the land used for grazing activities was predominantly in the range of 1-20 acres (38.2%, n=97). These results reveal a fact that the dominant land acreage of up to 20 acres owned by most respondents was almost utilized entirely for livestock production. This close range of the land size owned by respondents and the portion which is allocated to grazing signifies the importance of livestock production in the livelihoods of pastoralists in South-western Uganda. In some other areas in Uganda where livestock production is practiced, cattle farmers have been reported to own an average of 40 acres where a small portion (23%) of their land is allocated to cattle keeping (Turinawe et al., 2012). Cattle was the major type of livestock kept (99.6%, n=249) and these were dominated by Friesian crosses with most farmers keeping up to 20 heads (39.2%, n=98) per household. The dominance of Friesian crosses as opposed to the traditional Ankole long horn cattle is largely due to farmers' shift from the traditional subsistence to market-oriented livestock farming to benefit from the high demand for livestock products especially milk in the country (Ntakyo et al., 2020). This creates a demand for a consistent supply of feed resources to sustain livestock production.

This study further reports open grazing as the major practice of livestock production (83.2%, n=208) and shortage of pastures was highly reported (66.0%, n=165), (Table 2). This could be explained by exclusive feeding of the livestock on the range pastures as continuous overgrazing leads to replacement of productive perennial pasture species by unpalatable low quality annual species (Atuhaire et al., 2018). More so, the intensive livestock feeding systems in open grazing have been linked to the decline in soil properties including structure and organic matter content (Bolo et al., 2019), which in turn negatively affect the growth potential of range pastures leading to pasture shortage.

Soil moisture conservation and nutrient management practices used in the range pastures

Agroforestry, where different tree species were retained/ integrated in the range pastures was the major soil moisture conservation and nutrient management practice reported (87.6%, n=219), (Figure 3). A total of 27 tree species (belonging to 16 families) were reported to be retained/ integrated in the grazing lands (Table 3). Over 80% of the reported tree species were indigenous and these were dominated by *Acacia hockii*, *Acacia gerrardii*,

Table 1. Socio-demographic profile of the households.

Variable	N	%
Gender		
Male	155	62
Female	95	38
Age (years)		
20-30	15	6.0
31-40	27	10.8
41-50	61	24.4
51-60	74	29.6
61-70	46	18.4
>70	27	10.8
Education level		
None	71	28.4
Primary	79	31.6
Secondary	63	25.2
Tertiary	37	14.8
Marital status		
Single	8	3.2
Married	218	87.2
Separated	5	2.0
Widow/widower	19	7.6

Source: Descriptive statistics from primary survey data (2017).

Albizia coriaria and *Ficus natalensis*. The integrated tree species included; *Mangifera indica, Psidium guajava, Grevillea robusta* and Eucalyptus spp. Other than agroforestry, other practices but less commonly used included addition of manure (0.8%, n=2) and integration of pastures with legumes (0.4%, n=1). Some respondents (11.2%) did not report any practice.

The dominance of agroforestry as a soil moisture conservation and nutrient management practice in range pasture management highlights a complementary value of tree species in the productivity of range pastures. Several studies have reported higher productivity of range pastures under tree canopies (Siqueira et al., 2017; Gomes et al., 2020) due to higher organic matter content up to 6.96% and higher levels of soil nutrients compared to tree less sites (Nabasumba et al., 2021). Previous studies attribute the use of agroforestry in soil moisture conservation and nutrient management in range pastures to farmers' understanding of ecological requirements of production systems which dictate the mixture of tree species (Dumont et al., 2019). Such findings complement the results of this study where different indigenous tree species occurring in different response frequencies were retained by farmers to improve the productivity of range pastures in the grazing areas of South-western Uganda.

Chi-square test of independence performed to examine the associations between soil moisture conservation and nutrient management practices and age, gender, education level, marital status, land size owned, land size used for grazing, number of indigenous and cross bred cattle, and grazing system revealed a significant relationship with marital status X^2 (9, N=250) =25.052, p = 0.003) and grazing system X^2 (6, N=250) = 16.709, p = 0.01) of the respondents. Up to 88.1% of the respondents that retained/integrated tree species in the range pastures for soil moisture conservation and nutrient management were married (Table 4). This portrays a complementary strength of husband and wife in decision making regarding use of tree species in range pasture management for sustainable livestock production. Gebru et al. (2019), reports a similar trend where women were actively involved in agroforestry practices including soil fertility improvement as their male counterparts. The linkage between the two studies highlights a need to capitalise on married category of livestock farmers in promoting agroforestry in range pasture management.

For grazing system, 85.8% of the respondents that used agroforestry practiced open grazing (Table 5). This is linked to the fact that open grazing was the dominant practice of livestock production reported by farmers. This practice replaced the traditional nomadic pastoralism

Table 2. Land and grazing characteristics of the households.

Variable	N	%
Land size (acres)		
1-20	78	31.2
21-40	46	18.2
41-60	42	18.2
61-80	24	9.6
>80	58	19.6
Land used for grazing (acres)		
1-20	97	38.2
21-40	44	17.6
41-60	36	10.8
61-80	20	8.0
>80	53	21.2
Livestock types		
Cattle	249	99.6
Goats	203	81.2
Sheep	96	38.4
Number of cattle (Indigenous)		
None	153	61.2
1-20	61	26.4
21-40	17	6.8
41-60	10	4.0
60	9	3.6
Number of cattle (Friesian crosses)		
None	20	8.0
1-20	98	39.2
21-40	47	18.8
41-60	29	11.6
61-80	17	6.8
>80	39	13.8
Grazing systems		
Open grazing	208	83.2
Rotational grazing/paddocking	41	16.4
Zero grazing (Cut and carry)	1	0.4
Pasture adequacy		
Yes	85	34
No	165	66

Source: Descriptive statistics from primary survey data (2017).

where tree species were part of cultural history of pastoralists for socio-economic and ecological functioning of grazing lands (Bergmeier et al., 2010). Ecologically, tree species have been reported to influence a wide range of light and shade conditions as well as small scale nutrient rich sites (Abdulahi et al., 2016) which factors have a bearing on soil moisture and nutrient levels and the corresponding growth of the range pastures. Thus, the significant association between agroforestry and open grazing in range pasture management reveals that

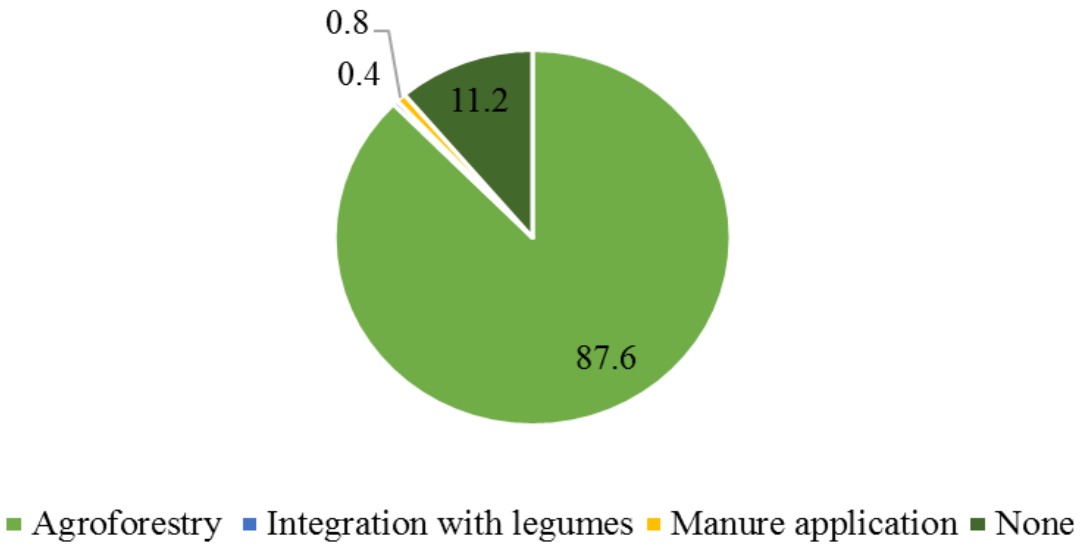

Figure 3. Soil moisture conservation and nutrient management practices used in the range pastures.
Source: Descriptive statistics from primary survey data (2017).

Table 3. Agroforestry tree species retained/integrated in the range pastures.

Tree species	Local name	Family	Cumulative frequency of responses
Acacia hockii De Wild.	Orugando	Fabaceae	106
Acacia gerrardii Benth	Omutongore	Fabaceae	103
Albizia coriaria Oliv.	Omusisa	Fabaceae	89
Ficus natalensis Krauss ex Engl.	Omutooma	Moraceae	76
Rhus natalensis Bernh. ex Krauss	Omusheeshe	Anacardiaceae	59
Acacia abyssinica Benth.	Omunyinya	Fabaceae	48
Erythrinna abyssinica DC.	Ekiko	Fabaceae	46
Grewia mollis Juss.	Omukoma	Tiliaceae	48
Acacia sieberiana DC.	Omutyaaza	Fabaceae	53
Euphobia candelabrum Tremaux ex Kotschy	Enkukulu	Euphorbeaceae	41
Eucalyptus spp	Kalitunsi	Myrtaceae	38
Allophylus africanus P. Beauv.	Omutete	Sapindaceae	23
Acacia campylacantha A.Rich.	Kibeere	Fabaceae	21
Grevillea robusta A.Cunn. ex R.Br.	-	Fabaceae	10
Psidium guajava Linn	Omupeera	Myrtaceae	9
Combretum molle R. Br. ex G	Emiragi	Combretaceae	6
Euclea latidens Stapf	Omusikizi	Ebeneaceae	6
Erythrophleum pyrifolia	Omurama	Fabaceae	6
Ficus ovata Vahl	Omukunyu	Moraceae	5
Mangifera indica L.	Omuyembe	Anacardiaceae	5
Jasminum pauciflorum Benth.	Akalemanjojo	Oleaceae	4
Nuxia congesta R. Br.	Omumuli	Loganiaceous	4
Maesopsis eminii Engl.	Omusizi	Rhamnaceae	3
Makhamia lutea (Benth.) K. Schum.	Omusyambya	Bignoniacea	3
Teclea nobilis Del.	Omuzo	Rutaceae	3
Maytenus senegalensis (Lam.) Exell	Omunyabiruko	Celastraceae	2
Chenopodium opulifolium Schrad. ex W.D. J.Koch and Ziz	Omujuma	Amaranthaceae	1

Source: Descriptive statistics from primary survey data (2017).

Table 4. Cross tabulation results of marital status and soil moisture conservation and nutrient management practices for range pastures.

			Marital status (%)				Total
			Single	Married	Separated	Widower	
Conservation/ management practices	Manure application	Count	0	0	0	2	2
		% within practices	0.0	0.0	0.0	100	100
	Integration with legumes	Count	0	1	0	0	1
		% within practices	0.0	100	0.0	0.0	100
	Integration with trees	Count	7	193	4	15	219
		% within practices	3.2	88.1	1.8	6.8	100
	None	Count	1	24	1	2	28
		% within practices	3.6	85.7	3.6	7.1	100
Total		Count	8	218	5	19	250
		% within practices	3.2	87.2	2.0	7.6	100.0

Source: Descriptive statistics from primary survey data (2017).

Table 5. Cross tabulation results of grazing systems and soil moisture conservation and nutrient management practices for range pastures.

			Grazing systems			Total
			Open grazing	Rotational grazing	Zero grazing	
Conservation/ management practices	Manure application	Count	0	2	0	2
		% within practices	0.0	100.	0.0	100
	Integration with legumes	Count	1	0	0	1
		% within practices	100	0.0	0.0	100
	Integration with trees	Count	188	30	1	219
		% within practices	85.8	13.7	0.5	100
	None	Count	19	9	0	28
		% within practices	67.9	32.1	0.0	100
Total		Count	208	41	1	250
		% within practices	83.2	16.4	0.4	100

Source: Descriptive statistics from primary survey data (2017).

livestock farmers take interest in maintaining the productivity of range pastures in a their mostly used grazing practice for sustainable livestock production.

Sources of information for soil moisture conservation and nutrient management practices in the range pastures

The dominant source of information for soil moisture conservation and nutrient management in the range pastures was farmers' own knowledge (49.1%, n= 54). Other sources included fellow farmers (24.5%, n= 27), extension officers (21.8%, n=24) and media (9.1%, n=10) (Table 6).

The dominance of farmers' own knowledge reveals limited flow of information on potential soil moisture conservation and nutrient management practices that can improve the productivity of range pastures. Whereas farmers' knowledge is crucial in pasture production

Table 6. Sources of information for soil moisture conservation and nutrient management in the range pastures

Variable	Response options	Responses		% of Cases
		N	%	
Sources of information[a]	Own knowledge	54	47.0	49.1
	Extension officer	24	20.9	21.8
	Fellow farmer	27	23.5	24.5
	Media	10	8.7	9.1
Total		115	100.0	104.5

[a]Dichotomy group tabulated at value 1.
Source: Descriptive statistics from primary survey data, 2017

Table 7. Constraints of soil moisture conservation and nutrient management in the range pastures.

Variable	Response option	Responses		% of Cases
		N	%	
Constraints[a]	Lack of funds	140	24.2	61.1
	Lack of access to materials	67	11.6	29.3
	Lack of information	154	26.6	67.2
	Risk on animal health	24	4.2	10.5
	Shortage of labor	86	14.9	37.6
	Shortage of land	77	13.3	33.6
	Lack of water	30	5.2	13.1
Total		578	100.0	252.4

[a]Dichotomy group tabulated at value 1.
Source: Descriptive statistics from primary survey data (2017).

systems, robust exposure of farmers to diverse technology dissemination pathways boosts learning and practice change through engagement with scientists, seeing relative advantage as well as re-informing and validating learned technologies (Sewell et al., 2017). Thus, the outstanding dependence on farmers' own knowledge reported in this study explains the dominance of agroforestry and especially the use of indigenous tree species in soil moisture conservation and nutrient management in range pastures. This is further emphasised by a fact that other than own knowledge, the second dominant source of information was through fellow farmers. Nevertheless, information flow through fellow farmers portrays a level of importance of farmer to farmer extension approach in technology promotion. A study by Kiptot and Franzel (2015), reports that farmer to farmer extension plays a complimentary role to formal extension services in the spread of agricultural technologies and improving farmers' capacities which findings collate with the results of this study.

Despite the existence of a public extension structure in the study districts (AfranaaKwapong and Nkonya, 2015), farmers' access to information on soil moisture conservation and nutrient management practices in range pastures through extension was very low. This implies that there is lack of adequate awareness and inclusion of information on the respective soil aspects in extension programs for livestock production activities. This limits farmers' ability to counteract the challenges of pasture shortage reported in the area through adoption of practices that can improve the growth potential of natural pastures.

Constraints of soil moisture conservation and nutrient management in the range pastures

Lack of information (67.2%, n=154) coupled with lack of funds (61.1%, n=140) were the major constraints of soil moisture conservation and nutrient management in the range pastures of South-western Uganda (Table 7). Results of multivariate regression analysis (Table 8) showed that lack of information was significantly associated with education level and grazing systems of respondents ($p<0.05$). In terms of education, Cross tabulation results indicated that the constraint was more pronounced (37.7% n=58; Table 9) among respondents who had primary status as their highest level of education while for grazing system, 90.3% (n=139) of the respondents who were constrained by lack of information

Table 8. Multivariate regression analysis for relationship between major constraints of soil moisture conservation and nutrient management and independent variables.

Source	Dependent variable	Type III sum of squares	df	Mean square	F	Sig.
Corrected Model	Lack of funds	1.296[a]	9	0.144	0.573	0.819
	Lack of information	7.148[b]	9	0.794	3.667	0.000
Intercept	Lack of funds	10.383	1	10.383	41.322	0.000
	Lack of information	10.604	1	10.604	48.953	0.000
Gender	Lack of funds	0.059	1	0.059	0.236	0.628
	Lack of information	0.176	1	0.176	0.811	0.369
Age	Lack of funds	1.001	1	1.001	3.985	0.047
	Lack of information	0.474	1	0.474	2.188	0.140
Education level	Lack of funds	0.131	1	0.131	.521	0.471
	Lack of information	1.885	1	1.885	8.703	0.003
Marital status	Lack of funds	0.004	1	0.004	0.015	0.903
	Lack of information	0.042	1	0.042	0.192	0.661
Land size	Lack of funds	2.955E-5	1	2.955E-5	0.000	0.991
	Lack of information	.017	1	0.017	0.080	0.777
Land for grazing	Lack of funds	1.498E-5	1	1.498E-5	0.000	0.994
	Lack of information	0.019	1	0.019	0.090	0.765
Number of indigenous cattle	Lack of funds	0.002	1	0.002	0.010	0.921
	Lack of information	0.006	1	0.006	0.027	0.870
Number of cattle crosses	Lack of funds	0.000	1	0.000	0.000	0.982
	Lack of information	0.019	1	0.019	0.089	0.766
Grazing system	Lack of funds	0.092	1	0.092	0.364	0.547
	Lack of information	2.210	1	2.210	10.201	0.002
Error	Lack of funds	60.304	240	0.251		
	Lack of information	51.988	240	0.217		
Total	Lack of funds	580.000	250			
	Lack of information	538.000	250			
Corrected total	Lack of funds	61.600	249			
	Lack of information	59.136	249			

aR Squared = 0.021 (Adjusted R Squared = -0.016);bR Squared = 0.121 (Adjusted R Squared = 0.088)
Source: inferential statistics from primary survey data (2017).

practiced open grazing (Table 10).

Whereas, significant efforts have been undertaken to ensure sedentarisation of pastoralists (Byakagaba et al., 2018), livestock farmers still lack adequate information on how to sustain soil productivity in the range pastures in such a settled production system. This is especially emphasised by the fact that majority of the respondents reported primary status as their highest level of education and practiced open grazing; and that is where the constraint was more significant. In comparison with the

Table 9. Cross tabulation results of lack of information and education level of respondents.

			Education level				Total
			None	Primary	Secondary	Tertiary	
Lack of information	Yes	Count	51	58	30	15	154
		% within lack of information	33.1	37.7	19.5	9.7	100.0
	No	Count	20	21	33	22	96
		% within lack of information	20.8	21.9	34.4	22.9	100.0
Total		Count	71	79	63	37	250
		% within lack of information	28.4	31.6	25.2	14.8	100.0

Source: inferential statistics from primary survey data (2017).

Table 10. Cross tabulation results of lack of information and grazing systems.

			Grazing systems			Total
			Open grazing	Rotational grazing	Zero grazing	
Lack of information	Yes	Count	139	15	0	154
		% within Lack of information	90.3	9.7	0.0	100.0
	No	Count	69	26	1	96
		% within Lack of information	71.9	27.1	1.0	100.0
Total		Count	208	41	1	250
		% within Lack of information	83.2	16.4	0.4	100.0

Source: inferential statistics from primary survey data (2017).

Table 11. Cross tabulation results of lack of funds and age of respondents.

			Age (years)						Total
			20-30	31-40	41-50	51-60	61-70	>70	
Lack of funds	Yes	Count	8	21	38	36	26	11	140
		% within lack of funds	5.7	15.0	27.1	25.7	18.6	7.8	100
	No	Count	7	6	23	38	20	16	110
		% within lack of funds	6.4	5.5	20.9	34.5	18.2	14.5	100
Total		Count	15	27	61	74	46	27	250
		% within lack of funds	6.0	10.8	24.4	29.6	18.4	10.8	100

Source: Primary survey data (2017).

results of Hyland et al. (2018), low access to information was the major constraint of range pasture improvement faced by livestock farmers. Failure to equip livestock farmers with appropriate information on soil moisture conservation and nutrient management practices for range pastures that takes into account their literacy levels risks wise use of grazing areas for sustainable livestock production.

For lack of funds, there was a significant association with age of the respondents ($p<0.05$) where the constraint was more pronounced in the age category of 41-50 years (27.1%, n= 38; Table 11).

More so, lack of funds equally revealed a significant constraint for livestock farmers to adopt soil moisture conservation and nutrient management practices for range pastures. This largely hinders investment into the diverse practices with potential for improving the productivity of range pastures. Similarly, financial related challenges such as increased cost price on improved forage seed to re-plant bare lands were among the key

constraints to improvement of range pastures in Mecha and North Achefer areas in Ethiopia (Shiferaw et al. (2018). Such similarity in livestock production challenges elsewhere in sub-Saharan Africa gives a hint on entry areas for improving the productivity of the natural pasture dependent livestock production systems in South-western Uganda. Dominance of the constraint in the age category of 41-50 years highlights the target group for financial interventions to aid farmers' investment in soil moisture management and nutrient conservation in the range pastures.

Conclusion

This study has shown that agroforestry through retention of indigenous tree species in grazing lands was the major soil moisture conservation and nutrient management practice used in the range pastures in South-western Uganda.

Farmers' own knowledge was the main source of information regarding soil moisture conservation and nutrient management in the range pastures followed by fellow farmers. However, the limited flow of information to farmers through extension officers has revealed limited awareness and inadequate inclusion of soil moisture conservation and nutrient management aspects for range pastures in extension programs for livestock production. Lack of information coupled with lack of funds was the major constraints experienced by farmers. The significant association of education level and lack of information calls for deliberate effort in development and effective dissemination of appropriate information materials that take into account the literacy level of majority of the respondents. Therefore, to enhance adoption of soil moisture conservation and nutrient management practices for range pastures, farmer participatory testing and adaptation of alternative practices alongside agroforestry is recommended. Inclusion of soil moisture conservation and nutrient management practices for range pastures should be made deliberate in extension programs for livestock production. More so, the study recommends financial incentives to livestock farmers to boost their capacity to invest in soil management practices for sustainable production of range pastures.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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