Factors Influencing the Level of Water Access for Livestock in Semi-Arid Areas of Monduli District, Tanzania

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Abstract

Access to water by livestock is critical for their growth, reproduction and quality of products. However, despite its relevance, water access for livestock has received comparatively little attention in developing countries Tanzania included. Therefore, the paper examines factors influencing water access for livestock in the semi-arid areas of Monduli district, Tanzania. A cross-sectional research design was adopted whereby primary data was collected using a pre-structured questionnaire discussions from 367 randomly selected pastoralist households. In addition, focus group discussions were used to allow triangulation. Quantitative data were analysed using Statistical Package for Social Sciences (SPSS) whereby both descriptive (frequencies and percentages) and inferential statistics were determined. An ordinal logistic regression model was used to determine the factors associated with livestock access to water. Qualitative data was analysed using content analysis. The findings show that the majority (76.3%) of households experienced low levels of water access for their livestock. Additionally, findings show that off-farm income, access to credit, access to subsidies and the use of donkey carts and or tied jerry cans onto donkeys were significantly associated with water access by livestock. The study concludes that most pastoralists in the Monduli district have a low level of water access for livestock. Therefore, it is recommended that all stakeholders in water and livestock sectors should come up with strategies that ensure pastoral communities have access to sufficient amounts of water for their livestock.

Keywords: Water access, livestock, pastoralists, semi-arid areas

Introduction

Water is a vital component in the body weight composition, growth, and reproduction of animals (Beede, 2012). According to Deutsch *et al.* (2010), the livestock sector consumes about 10% of the world's annual water flow. Wakchaure et al. (2015) adds that water creates 50% to 70% of an animal's live weight. In addition, King (1979) contends that cattle, goats and sheep consume 56.1, 5.4 and 5.2 litres per day. Equally important water access is defined as the ability of an actor especially a person, household, or group to access the community water resource as they require (Hamilton *et al.,* 2020). Water access for livestock refers to the nearness to a water source by the community, depicted by the distance to a water point (Opiyo *et al.,* 2011). In this study, water access for livestock refers to the ability of pastoralists to easily access water for their livestock's survival and production.

Generally, the distance walked by livestock to reach a water point is an important dimension for the measurement of water access for livestock. According to Holechek *et al.* (1998) the walking distance of not more than 3km to a water point is recommendable in the United States of America and Australia. However, Pallas (1986) argues that a walking distance of 6-10 km and 3–5 km is healthy for the cattle and goats respectively in the semi-arid livestock and Sahelian livestock areas. The study adopted a distance of 0-10km in determining the pastoralists livestock's access to water as the study area is semi-arid. In addition, 5 hours was used as the time spent by households in watering livestock, which included time taken by livestock from walking to the water point and drinking water

at the water point. According to Thompson *et al.* (2003) people in rural areas in East Africa spend three hours consuming improved water sources and five hours when using unimproved water sources. Iteba *et al.* (2021) have reported that cattle spend an average of 11.5 minutes in drinking water.

Further to the above, access to water is also determined by its affordability. Generally, water is affordable if a household's expenditure on the same does not exceed 3% of its income (Wang *et al.,* 2010; Kayser, 2013). Nonetheless, Cassivi *et al.* (2018) argue that the indicators for measuring household water access are multifaceted and they differ around the world. However, Daly *et al.* (2021) contend that the use of multiple water sources is a good dimension in the measurement of the level of water access both in urban and rural areas.

In Tanzania, about 40% of the semi-arid rangelands have access to water supply for livestock (URT, 2010). Generally, water access by livestock in semiarid areas has not improved for over four decades with the situation worsening in recent years (Kahimba and Niboye, 2019). Furthermore, van Eeden et al. (2016) argue that the existing legislation and water use permits favour the estate sector, large-scale agriculture development, and electricity supply. The legislations seem to ignore other sectors such as pastoralism. Moreover, the first priority is the development of the water sector for basic human needs (URT, 2002).

A review of literature has shown that past studies on livestock and water have generally focused on conflicts over water resource use between farmers and pastoralists (Matimbwa and Mwalimu, 2019; Falanta *et al.,* 2018); climate change and water for livestock (Mung'ong'o *et al.,* 2019; Magita and Sangida, 2017); and the impact of policy and legal reform on a pastoral system (Mattee and Shem, 2006; Onesmo, 2016). Other studies have focused on water use permits and water availability for livestock (Kahimba and Niboye, 2019), and the influence of water availability on pastoralists resource use (Opiyo *et al.,* 2011; Gettel *et al.,* 2019). Despite its relevance, water access for livestock in the semi-arid areas has received comparatively little attention in comparison to recyclable studies in developing countries (Pelletier and Tyedmers, 2010; Muganda and Croney, 2019; and Gettel *et al.,* 2019). Furthermore, the mentioned studies have not examined factors influencing the level of water access for livestock by pastoralists. Therefore, the study on which the paper is based examined the factors influencing the level of water access for livestock in the semi-arid areas of Monduli district, Tanzania. The study's findings have the potential to help decision-makers identify and prioritize places where the government and other water use stakeholders should intervene in order to access water by the livestock kept by pastoral communities in the semi-arid areas.

Theoretical Framework

The research is guided by the access theory which was developed by Ribot and Peluso (2003). According to the access theory, for an individual to obtain a resource, there must be a mechanism of access that is guided by technology, capital, markets, knowledge, authority, social identity, and social relations (Koch, 2008). The study employed only three factors that guide the mechanism of access to resources including household capital, technology and institutions. Three factors for access mechanisms were chosen for this study because they change depending on various circumstances. Some of the circumstances include location; time and power dynamics (Ribot and Peluso, 2003). The theory of access was used because it has made an important contribution to understanding access to natural resources by specifying various mechanisms that guide resource access (Ribot and Peluso, 2003). In this study, institutions are referred to as required structures since the current social environment, by implication, is unable to offer the delivery or supporting facilities and services (Jiggins and Hunter, 1979). Furthermore, North (1991) contends that organizations must be viewed as a type of institution in which the individuals within it play an important role. Bunker (1985) asserts that technology is something that keeps an individual away from a resource or enables an individual to reach a resource. In this study, technology refers to the thing that simplifies the pastoralist's household

to access water for their livestock. Examples of technology related to water access for livestock include the use of a donkey cart and or tied jerry can onto donkey and motorcycle and tractor water bowser to transport water for livestock. Also in this study capital, refers to things that a person or a household can utilize individually or in combination to make a living.

Conceptual framework

The study's conceptual framework (Fig. 1) shows how the background variables, independent variables and dependent variables interact. Its assumed that the background variables (age, sex, marital status and education level of the household head, household size, household income/assets), independent variables (institutions, involvement in other income generating activities, technology, ownership of modes of transport such as cars, motorcycles, tractors etc., access to credit, climate change) and intermediate variables (policies and government strategies) directly or indirectly influence the dependent variable (i.e. livestock's access to water).

According to the literature, literate households with high education levels, particularly the household head, positively influence water access compared to those without education or with a low level of education (Gomez *et al.,* 2019; Aikowe and Mazancová, 2021; Akoteyon, 2019). Furthermore, past research indicates that household assets and or capital such as finance, knowledge and social (Balfour, 2019; Young *et al.,* 2022), and use of technology, positively influence water access in rural areas (Mwasame, 2020; Yator and Kwasira, 2020). Furthermore, Oksen and Favre (2020) argue that technology plays a significant role in delivering resource-efficient solutions to some of the difficulties associated with water accessibility. Additionally, previous studies demonstrate that household size and age have a negative influence on water accessibility (Aikowe and Mazancová, 2021; Gebremichael *et al.,* 2021).

Methodology

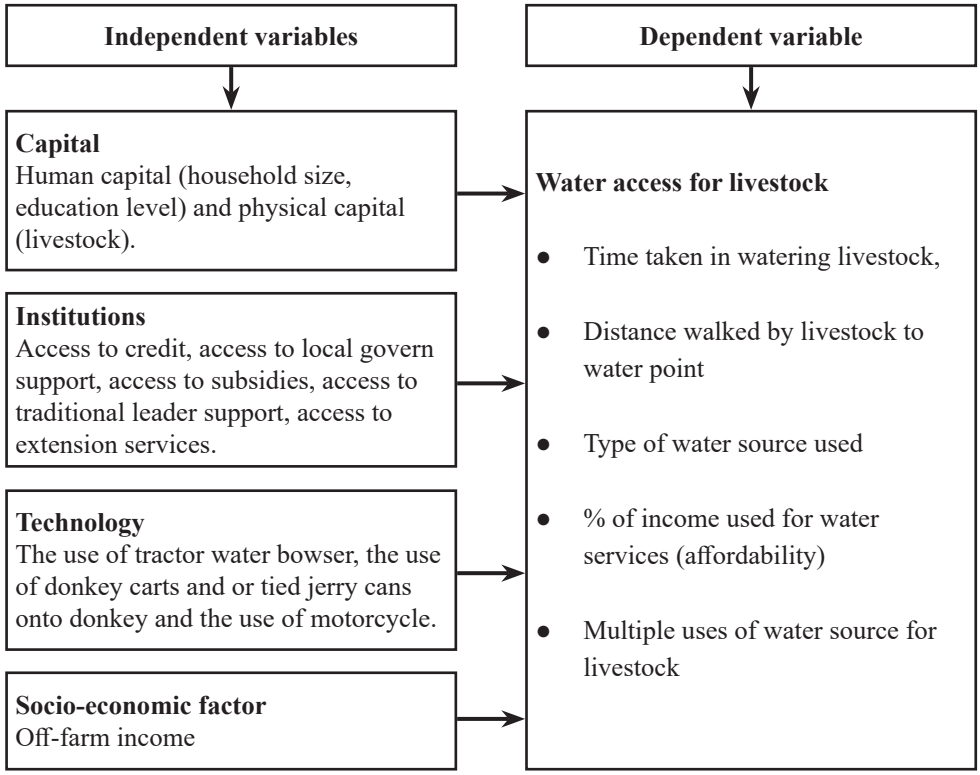

Figure 1: Conceptual framework of the study adapted from Ribot and Peluso (2003)

Description of the study area

Monduli district is one of the seven districts in the Arusha Region; the others are Arusha, Meru, Karatu, Monduli, Longido and Ngorongoro. The district is located between latitudes 3°15' and 3°55′ South and longitudes 35°55′ and 36°40′ East. The district is characterized by climatic variations that include drought and unpredictable rainfalls (Kimaro *et al.,* 2018) that range between 200mm and 600mm (Kaswamila, 2009). Monduli district was selected because it has a lowland ecological zone with both arid and semi-arid climates where livestock keeping is the main economic activity (Kimaro *et al.,* 2018). The research was carried out in Makuyuni and Moita wards, which form part of the district's twenty wards, the two were selected because they are located in the low-land ecological zone that is suitable for livestock keeping. Thereafter, seven villages i.e. Makuyuni, Naiti, and Mbuyuni (Makuyuni ward) and Moita Kipoki, Moita Kiloriti, Moita Bwawani, and Kilimatinde (Moita ward) were selected.

Research design and sampling procedures

The study used a cross-sectional research design whereby data was collected once (Babbie, 1990). The design also allows the researcher to get a comprehensive picture of the problem being investigated (Clark and Ivankova, 2016). The study's population was all pastoralists in the two wards mentioned above. Pastoralism is a mode of subsistence that involves raising domestic animals in grassland environments using herd and household mobility (Djordjević-Milošević, and Milovanović, 2019). According to the URT (2012), Makuyuni has 1159 households, Naiti has 465, Mbuyuni has 556, Moita Kipoki has 470, Moita Kiloriti has 533, Moita Bwawani has 754, and Kilimatinde has 453. Based on the available households' population in each village, simple random sampling was used to select a total sample of 367 respondents computed by using the Yamane (1967) formula presented in equation (i).

$$n = \frac{N}{1 + N(e)^2} = \frac{4{,}390}{1 + 4{,}390(0.05)^2} = 367 \quad \text{(i)}$$

Where n = sample size, N is the population size = 4390 and e is the level of precision (sampling error) = 5%.

$n = 4390/1+4390(0.05)^2 = 367$

From a total of 367 respondents selected for an interview, in each village, the respondents were selected proportionally by using Salkind (2010) formula presented in equation (ii). Table (1) summarizes the number of respondents computed in each village.

$$n_b = \frac{N_h}{N} \text{x } n \quad \text{(ii)}$$

Whereby n_b is the sample of the village, N_h is the population of the village, N is the total population of all villages and n is the total sample size for the study computed from all seven selected villages in equation (i). Taking an example of Makuyuni village, the computation was illustrated below. The same procedure was used to calculate the sample size for each village.

$n_b = 1159/4390 \times 367 = 96.89 \approx 97$

Table 1: Sample size determined in each village

Ward	Village	Sample size
Makuyuni	Makuyuni	97
	Mbuyuni	46
	Naiti	39
Moita	Moita Kipoki	39
	Moita Kiloriti	45
	Moita Bwawani	63
	Kilimatinde	38

Data Collection

A mixed methods research approach was used to collect primary data comprising of both quantitative and qualitative data. According to Green *et al.* (2015) mixed research methods have so much to offer such as abundant data, can achieve data saturation and a complete presentation of the study outcomes. Quantitative data were collected from 367 pastoralist household heads using a pre-structured questionnaire and focus group

discussions (FGDs), key informant interviews and field observation were used to collect qualitative data. A total of nine (9) Focus group discussions (FGD) were held, with four FGDs composed of men only conducted in Moita ward and similar three FGDs conducted in Makuyuni ward. Women speak less when they are mixed with men during the FGD (Stewart *et al.,* 2002). In this regard, one FGD composed of women only was held in each ward, making two female FGDs. Each FGD was composed of 6 to 10 individuals, which according to Mishra (2016) is an appropriate number for a FGD. Also, a total of sixteen (16) key informants including three rural water sanitation authority officers, seven village executive officers, two ward executive officers, two extension officers, and two traditional leaders were interviewed using a checklist.

Data Analysis

Quantitative data collected were analysed using the Statistical Package for Social Sciences (SPSS) version 20. The analysis included determination of descriptive statistics (frequencies and percentages) and factors associated with livestock's access to water whereby an ordinal logistic regression model was used. Water access for livestock was measured using the following variables; multiple use of water, types of water source used in watering livestock, livestock walking distance to water sources, time taken in watering livestock and affordability. By using Vinti (2020) summation formula water access variables were used to compute water access for livestock index score (WALIS).

$$WALIS = \sum_{I=1}^{n} xi \quad \text{(iii)}$$

Where:

WALIS=Water Access for Livestock Index Score

i=Indicator for water access (1=multiple uses of water, 2=type of water source, 3=distance walked by livestock to water source, 4= time taken in watering livestock, 5=Affordability)

n=Total number of indicators i.e. 5

Xi=Score of the respondent on i^{th} indicator

Summation of scores for each respondent derived from the five dimensions of water access for livestock was carried out with the highest and least scores being 8 and 0, respectively. The respondents were then categorized into high water access (scores ranging ≥ 5), medium water access (3 to <5) and low water access (0 to ≤3).

Additionally, the established water access for livestock indices was then subjected to an ordinal logistic regression model to predict the factors influencing water access for livestock. The ordinal logistic regression model was applied which according to Koletsi and Pandis (2018) is more powerful, convenient and flexible because it allows the use of ordinal categorical dependent variables in the analysis. An ordinal categorical variable is one which according to Dettori and Norvell (2018) can be placed in distinct order or hierarchy. Therefore, since the study's dependent variable is ordered the ordinal logistic regression model was used to examine the factors influencing the level of water access for livestock.

$$Logit(Y)=\beta 0+\beta 1X1+\beta 2X2+\ldots+\beta nXn+\varepsilon \quad \text{(iv)}$$

β0 = Y intercept

βi = régression coefficients

ε = error term

Y= Dependent variable (level of water access) ranges from 1 to 3 corresponding to 3 point scale levels of: (3) High, (2) Medium, (1), Low.

Where X1 …Xn are independent variables.

β1 and βn = coefficient of independent variable.

The dependent variable used for this study was "water access for livestock" (hereafter WAL) at the household level. Water access for livestock (dependent variable) which was ordinal variable was measured using the following variables;

- Multiple uses of water (1=water source has multiple uses 0=otherwise).
- Types of water source used (1=improved water source, 0=unimproved water source).
- Distance walked by livestock to water sources (2= 0-10km, 1= 11km - 20km, 0= 20km kilometers).
- Time taken in watering livestock (2=0-5hours, 1=6-10 hours, 0=>10 hours).
- Affordability of water supply services (1= household used < 3% of household income

(affordable for water access) 0 = otherwise (not affordable).

The independent variables were measured as follows:

- Household size (a form of human capital) is the total number of individuals in the household.
- Attended primary education and above (a form of human capital). Dummy, =1 otherwise =0.
- Never attended school (non-formal) (a form of human capital). Dummy, =1 otherwise =0.
- The Total number of livestock owned by household (herds size) measured in Tropical Livestock Unit (TLU).
- Access to credit (institutional). Dummy, access to credit=1, Otherwise =0.
- Access to village government support (institutional). Dummy, access to village government support =1 otherwise =0.
- Access to subsidies (institutional). Dummy, access to subsidies =1, Otherwise =0.
- Access to extension services (institutional). Dummy, access to extension service=1, Otherwise =0.
- Access to traditional leaders' support (institutional). Dummy, access to traditional leaders support =1 otherwise =0.
- Use of tractor water bowser in transporting water for livestock (technology) =1 otherwise = 0
- Use of motorcycle in transporting water for livestock (technology) =1, Otherwise = 0.
- Use of donkey cart and or tied jerry can onto donkey in transporting water for livestock (technology) =1, Otherwise = 0.
- Total off-farm income of household measured in Tsh

It is critical to investigate the problem of multicollinearity among the explanatory variables before estimating the model parameters (Hair *et al.,* 2010). To find multicollinearity among the independent variables, the variance inflation factor (VIF) was used. The model assumption was tested by using the proportional odds assumption (parallel lines regression assumption) to check the validity of the model. Furthermore the Pseudo R^2, namely, Cox and Snell R^2 and Nagelkerke R^2 were used to measure the goodness of fit of the model. These indices explain the proportion of the variation in the dependent variable to that of the independent variable in the model (Hemmert *et al.,* 2016). Additionally, McFadden R^2 was also utilized to see whether the model was appropriate or not for the data. Last, of all, qualitative data were analyzed by using the content analysis method. Content analysis was used to conceptualize and summarize qualitative data from Focus Group Discussions and Key Informant Interviews. The researcher taped the interviews and transcribed them into appropriate themes for discussion.

Results and Discussion

This section presents the results on the level of livestock water access by pastoralists, followed by investigating the relationship between socio-demographic factors and the level of water access for livestock using a chi-square test. In addition, it presents the ordinal logistic regression analysis results in relation to factors that influence the level of water access for livestock.

Level of water access for livestock

Five elements including walking distance to the water source, time taken in watering livestock, affordability, type of water source and multiple uses of water source were combined together to establish Water Access for Livestock (WALI) index to identify the high, medium and low level of water access for livestock as explained in the methodology section. The overall results show that a few (2.5%) of the surveyed households had high water access for livestock (Table 2). This implies that respondents with a high level of water access for livestock covered less distance to water points spent less time to reach the same and used improved water sources. In addition, they spent less than 3% of household income to cover water costs and had multiple uses of water sources used for livestock (Table 2).

Furthermore, chi-square results ($\chi 2$=188.8, df=12, p=0.000) in Table 2 indicate that the level of water access for livestock differs significantly between villages. This implies

Table 2: Level of water access for livestock in the study area

Location	Level of water access for livestock						
		Low		Medium		High	
	no	nL	%	nM	%	nH	%
Moita Kipok	39	37	94.9	2	5.1	0	0
Moita Kilorit	45	45	100	0	0	0	0
Moita Bwawani	63	60	95.2	3	4.8	0	0
Kilima tinde	38	28	73.7	10	26.3	0	0
Makuyuni	97	38	39.2	50	51.5	9	9.3
Mbuyuni	46	41	89.1	5	10.9	0	0
Naiti	39	31	79.5	8	20.5	0	0
TOTAL	**367**	**280**	**76.3**	**78**	**21.3**	**9**	**2.5**

Note: no = overall number/frequency, nL, nM and nH= Frequency for low, medium and high water access, Chi-square=188.8; df=12; p=0.000; Significant at 5% level; n=frequency

that there is significant difference between the location of respondents and level of water access for livestock. For example, the results show that only Makuyuni village few respondents accounting for 9.3% had high water access for livestock as compared to the other six villages. It was further pointed out during the FGD at Makuyuni village that high water access was possible for a few pastoralists' households with the financial means to pay for water charges, own boreholes and those with the capacity to hire water bowsers to supply water for their livestock. It was further reported that the water charges for livestock were 50 Tanzania shillings (THS) per head of cattle and 30 THS per head of sheep and goat. The findings suggest that affordability for water charges and availability of different types of water sources served as useful indicators for the high level of water access for livestock.

The study's observation differs from that of Balfour *et al.* (2020), who reported that just 7% of the pastoralist households in Wamba ward, Samburu East in Kenya, had high water access for livestock. On the other hand, the findings of this study are comparable to those of Tofu *et al.* (2023), who revealed that pastoralists in the Borana zone of South Ethiopia encountered 80% water scarcity for livestock and other uses.

In addition, the findings revealed that 76.3% of pastoralists have limited access to water for their livestock (Table 2). During the FGDs in Moita Kilorit, Moita Bwawani, and Moita Kipoki villages, it was also reported that pastoralists walked long distances to the water points, spent more time watering livestock due to long queuing, and paid watering livestock charges ranging from 10TSHs to TShs.50 per sheep or goats and TShs. 50-100 per cattle or donkey. Similarly, during the FGD at Moita Kilorit village, it was reported that low water access for livestock was due to several factors such as the collapse of the Moita dam, regular breaks in MONALO project water pipes, and a lack of other alternative water sources for livestock in their area. The findings are in line with what was reported by the key informant, Monduli District Rural Water Supply and Sanitation Officer who said that;

"…The Moita, Naralami, and Lokisale (MONALO) water project's pipelines are frequently broken. Locally employed water technicians are incompetent and used to allow more water to flow than the piping infrastructures could handle resulting in bursts of water pipes. Also, the water pipelines were frequently broken by children who were grazing the livestock who did so to get drinking water during grazing with a view to quench their thirst…." (Key informant, Monduli RUWASA office, 5th August 2020).

This implies that the low level of water access for livestock is a combination of factors including the lack of reliable water sources,

walking the long distance to reach water points, high water charges and poor water management. This finding differs from that of Kahimba and Niboye (2019) who revealed that pastoralists in the Ruaha Basin Tanzania experienced low access to water for livestock due to the lack of water use permits which was in favour of farmers as compared to the pastoralists. Also, similar findings were presented by Rweyemamu (2019) and Awinia (2020) in studies conducted in Mvomero and Kilosa districts which reported limited water access for livestock.

Socio-demographic characteristics and water access for livestock

The results in Table 3 show that more than 70% of all age categories among respondents ranging from ≤36 to > 56 have low water access for livestock. Equally important, chi-square results (df=4, $\chi 2$ =3.741, p=0.442) indicate that there is no significant difference between the age categories of the respondents and levels of water access for livestock acquired by the respondents. This finding implies that regardless of age most of the respondents in the study area have low water access for livestock. Therefore, they walk long distances, use more time (≥ 5 hours), not have affordable water services because household spend more than 3% of their household income on water access and used more unimproved water sources (unprotected water sources such as dams, rivers) to secure water access for livestock. Moreover, the study finding implies that the respondents have fewer multiple uses of water sources for livestock. This finding is contrary to that of Simelane *et al.* (2020) conducted in Eswatini which found that the respondents aged 35-54 and 55 years and above have low water access as compared to those with younger ages.

The results in Table 3 indicate that male headed households 76.9% were leading with the low level of water access for livestock as compared to their counterpart female headed households 25%. This finding implies that most of the women headed households 75% walk less

Table 3: Socio-demographic characteristics and water access for livestock (n = 367)

Variable		Level of water access for livestock						Chi-square		
		Low		Medium		High				
Age	no	nL	%	nM	%	nH	%	d	$\chi 2$	p-value
≤36	40	35	87.5	5	12.5	0	0			
36-56	231	172	74.5	52	22.5	7	3			
>56	96	73	76	21	21.9	2	2.1	4	3.741	0.442
Sex										
Male	363	279	76.9	75	20.7	9	2.5	2	6.990	0.030
Female	4	1	25	3	75	0	0			
Household size										
1-3	14	11	78.6	3	21.4	0	0			
4-6	71	49	69	20	28.2	2	2.8	4	2.999	0.558
>7	228	220	78	55	19.5	7	2.5			
Education										
Never attended school	169	128	75.7	35	20.7	6	3.6			
Primary education and above	198	152	76.8	43	21.7	3	1.5	2	2.185	0.702
Marital status										
Monogamous	170	126	74.1	40	23.5	4	2.4			
Polygamous	193	152	78.8	36	18.7	5	2.6	4	3.325	0.505
Single	4	2	50	2	50	0	0			

Note: no = overall number/frequency, nL, nM and nH= Frequency for low, medium and high water access, * indicates significant at 5%

distance during the watering of livestock, spent less time (≤5 hours), spent less income (≤3% of household income) and used less unimproved water sources as compared to male headed households. It was further confirmed during FGDs both in Naiti and Makuyuni villages that women were spared queuing during watering to allow them quick access to watering livestock and return home early to perform other domestic duties. This implies women spend less time watering livestock as compared to men. This finding is contrary to that of Sani and Scholz (2022) conducted in rural Nigeria which revealed that 90% of female head household spend more than 30 minutes and walk a distance of at least 1000m to fetch water.

Furthermore, the study findings are supported by Chi-square results ($\chi 2$= 6.990, df=2, p=0.030) which indicate that there is a significant difference between the sex of the respondents and the level of water access for livestock. This finding is contrary to that of Ngarava *et al.* (2019) conducted in South Africa and that of Agbadi *et al.* (2019) conducted in Ghana which all found that most female-headed households have high access to improved water sources as compared to male households.

In terms of donkeys, 75% of female-headed households raise them with the intention of using them to fetch water for livestock, domestic purposes, and other needs, compared to 62.5% of male-headed households. This suggests that pastoralists keep donkeys for water-fetching purposes using methods such as donkey carts or tying jerry cans onto donkeys. However, when comparing livestock ownership, 100% of female-headed households keep goats, sheep, and cattle, while nearly 95% of male-headed households do the same.

Household size is one of the important factors that determine household water access investigated in this study. Furthermore, Dungumaro (2007) contend that the large the household, the more income is spread and the higher poverty levels which eventually leads to the use of unimproved water sources (low water access). The results in Table 2 show that more than 65% of all household categories have a low level of water access for livestock. Additional Chi-square results ($\chi 2$= 2.999, df=4, p=0.558) indicate that there is no significant difference between household size and the level of water access for livestock. This implies that there is no significant difference between household size and the level of water access for livestock acquired by the household. This finding is similar to that of Abubakar (2019) conducted in Nigeria which found that there is no significant difference between water access and household size.

The findings in Table 3 regarding education show that all respondents have more than 75% low level of water access for livestock regardless of the education level of the respondents. These results are supported by Chi-square results ($\chi 2$= 2.185, df=4, p=0.702) which show that there is no significant difference between the level of education of the respondents and the level of water access for livestock. This implies that there is no significant difference between the education level and the level of water access by household. Similar findings are reported by Simelane *et al.* (2020) and Balfour *et al.* (2020) who revealed that there is no significant difference between the education level of the heads of households and water accessibility.

Marital status is an important socio-demographic characteristic examined in this study. With regards to the polygamous and monogamous household heads the results in Table 3 indicate that more than 70% have a low level of water access for livestock. Also, the results indicate that 50% of single household heads have a low level of water access for livestock. Furthermore, Chi-square results ($\chi 2$= 3.325, df=4, p=0.505) show that there is no significant difference between marital status and the level of water access for livestock. The study findings differ with that of Saladi and Salehe (2017) conducted in Handeni District Tanzania which found that marital status positively significantly influences water access.

Factors influencing the level of water access for livestock

Off-farm income

Off-farm income is one of the important factors influencing water access investigated in this study. The model results in Table 4 confirm a positive association between off-farm income

and the level of water access for livestock with a (p-value of 0.050, and an odds ratio of 1.054) at $p<0.05$. This implies that respondents with off-farm income had a 1.054 times likelihood of being in a higher level of water access for livestock than those without off-farm income. These findings suggest that as off-farm income increases, so does the level of water access for livestock. This is due to the fact that off-farm income provides surplus income that supports the payment of water charges for livestock. The findings are consistent with the findings reported from the key informants interview which revealed that pastoralists diversified into off-farm income generating activities to earn money for paying water charges for livestock. A village chairperson from Moita Village had this to say:

"Small businesses and livestock brokerage activities are used by people who do not have enough livestock or do not want to sell their livestock to cover the expense of livestock water supply. They generate money that they later on use to buy water for their livestock during droughts" (Key informant, Moita village, 25th July 2020).

This implies that off-farm income complements pastoralist's income to pay for water charges for livestock. These findings are in line with Mengistu (2021) conducted in Northern Ethiopia found that an increase in off-farm income in a household leads to an increase in the level of water access for livestock due to the surplus income supporting water access charges for livestock.

Access to credit

Access to credit is very important among pastoralists as it serves as an alternative mechanism for supplementing funds for purchasing water services for livestock in rural areas. The model results in Table 4 indicate a positive significant association between access to credit and the level of water access for livestock with a (p-value of 0.003, and odds ratio of 1.003) at $p<0.05$ (Table 4). This implies that those with access to credit had a 1.003 times likelihood of being in a higher water category of water access for livestock than those who do not have access to credit. Furthermore, it was also informed during FGDs at Moita Kilorit and Naiti villages that the majority of men in the dry season accessed credit for paying water charges for livestock from their wives who were members of the Village Community Banks (VICOBAs). Thus, suggesting access to credit serves as a strategy to address the water scarcity challenge. Generally, access to the credit allowed the pastoralists to pay for their livestock's water requirements during the dry season. The study's observation conforms with what has been reported by Adicha (2020) in southern Ethiopia which revealed that access to credit among agro-pastoralists enabled them to pay for water charges for their livestock. In addition, the finding is in line with what was reported during the key informant interviews as supported by the quote bellow:

"Some pastoralists have joined savings and loan groups (VICOBA) and lend the money to feed and water their livestock during dry seasons, then sell the livestock when the prices are good" (Key informant, Makuyuni village, 30th July, 2020).

Access to subsidies

Access to subsidies is one of the factors investigated in this study. The model results in Table 4 show a positive and significant a (p-value ≤ 0.001) association between access to subsidy and the level of water access for livestock. The results also suggest that households with access to subsidies had a higher likelihood of their livestock having access to water access for the livestock relative to those without access to subsidies. Also, it was reported during FGDs at Naiti and Mbuyuni villages that had access to subsidies in form of plastic lined materials from World Vision Tanzania enabled pastoralists to construct water infrastructures for watering livestock, particularly charco dams. Also, this information is supported by a Livestock Officer from the Makuyuni ward who said:

"World Vision Tanzania has offered plastic lined materials and charco dam manufacturing training to pastoralists in the Naiti and Mbuyuni villages, and they are currently harvesting water for livestock and domestic use" (Key informant, Makuyuni Ward, 22nd July 2020).

The study's findings suggest that access

Table 4: Ordinal Logistic Regression Results Showing Factors Associated with the Level of Water Access for Livestock (n=367)

Variables	Estimate	Std. Error	Wald	df	Sig.	Odd ratio	95% C.I. for		Collinearity statistics	
							Lower	Upper	VIF	1/VIF
Socio-economic										
Off farm income	5.881E-8	0.000	3.632	1	0.050**	1.054	-1.668E-9	1.193E-7	1.03	0.972
Household capital										
Herds size (TLU)	0.001	0.001	0.600	1	0.439	1.551	-0.003	0.001	1.61	0.620
Household size	0.017	0.015	1.316	1	0.251	1.285	-0.012	0.047	1.067	0.937
Never attended school	0.208	0.224	0.865	1	0.352	1.421	-0.231	0.647	1.042	0.959
Attended primary education and above	0.267	0.413	0.418	1	0.518	1.679	-0.542	1.076	1.264	0.791
Institution										
Access to credit	0.888	0.300	8.745	1	0.003**	1.003	0.299	1.476	1.174	0.852
Access to village government support	0.301	0.262	1.322	1	0.250	1.284	-0.212	0.814	4.605	0.217
Access to subsidies	1.600	0.272	34.658	1	0.000**	1	1.068	2.133	1.150	0.870
Access to extension services	0.232	0.289	0.642	1	0.423	1.527	-0.335	0.799	5.407	0.185
Access to traditional leaders support	0.042	0.304	0.019	1	0.890	2.435	-0.553	0.637	4.110	0.243
Technology										
Use of tractor water bowser	0.001	0.268	0.000	1	0.997	2.710	-0.524	0.526	1.11	0.899
Use motorcycle	0.218	0.221	0.973	1	0.324	1.3826	-0.215	0.650	4.158	0.241
Use of donkey cart/tied jerry can onto donkey	0.519	0.239	4.706	1	0.030**	1.030	0.050	0.988	1.13	0.886

-2 Log Likelihood (Intercept Only=779.226; Final=692.593; Chi-Square=86.633; df=13, p=0.000; Cox and Snell=0.211; Nagelkerke=0.239; McFadden=0.111 Pearson chi-square=707.047; df=716; p=0.587; Deviance chi-square=692.593, df=716 p=0.728. Test for parallel lines (General chi-square=3.419, df=12; p value=0.07; **Significant at 5% level; Tropical Livestock Unit (TLU) refers to livestock units owned by households (Njuki, 2011), TLU for mature cow=1, sheep=0.20, oxen=1.42, donkey=0.80, heifer=0.78, poultry=0.04, bull=1.20 and calve=0.41.

to subsidies led to a reduction of the costs for the construction of water infrastructures such as charco dams hence, increasing water access by the livestock. The study's findings are in line with Kattel (2015) who reported access to subsidies in Nepal was associated with increased access to water as it enabled the construction of water supply infrastructures in rural areas.

Pastoralists use donkey carts and or tied jerry cans onto the donkey

The use of donkeys together with carts and or tied jerry cans onto donkeys is recognized as a suitable and affordable technology for people in transporting water and other commodities in rural areas (Starkey and Starkey, 1997; Aganga and Tsopito, 1997; Ho *et al.,* 2021). Pastoralists use of donkeys in fetching water is common in

the semi-arid rural areas of Northern Tanzania (Swai and Bwanga, 2008). Study findings in Table 4 show that use of donkeys was positively and significantly (p-value ≤ 0.05) associated with the level of water access by the livestock owned by pastoralists. The results show that households using donkeys to transport water for livestock had a higher likelihood of their livestock having high access to water compared to those not using the donkey cart or tied jerry cans onto the donkey. In addition, during the FGDs in the study villages (Moita Kilorit, Moita Bwawani, Naiti and Kilima tinde) it was pointed out that donkey carts or tied jerry cans onto donkey were used to carry water for domestic use, calves, and sick livestock that grazed near the homestead. Furthermore, it was reported during the FGD at Naiti village that pastoralists preferred using donkeys compared to other modes of transport such as the tractor water bowser and motorcycles because most of the roads leading to the water points have canyons and stones that made them impassable. The above is supported by the quote bellow:

"A donkey is a livestock that is cared for by women and is used to fetch water for sick livestock, calves, and domestic purposes. Every Maasai household should also have a donkey for delivering water and other commodities such as farm products, according to the Maasai custom" (KI, Moita Ward, 16th July, 2020).

The study findings suggest that pastoralists are compelled to use donkeys to fetch water due to difficult environments such as gorges and droughts. The findings of the study match those of Mwasame (2020) who contends that almost 80% of the respondents in Kiambu County, Kenya, used donkey carts or tied jerry cans onto donkey to fetch water as their primary activity.

Conclusion and Recommendations

Conclusions

The study shows that most pastoralists in the Monduli district have limited access to water for their livestock. As a result, pastoralists must walk long distances and waste a lot of time looking for water for their livestock. This circumstance has also led to the use of unimproved water sources, difficulty to fund livestock water expenses, and limited use of livestock water sources for other development activities. The study concludes that factors influencing the level of water access for livestock by pastoralists in Monduli District are off-farm income, access to credit, access to subsidies and technology particularly the use of donkey carts or tied jerry cans.

Recommendations

Based on the study findings and conclusions the following are recommended: The local governments should come up with short and long-term strategies aimed at increasing pastoralists access to water both for their household's consumption and livestock. Pastoralists need to form groups through which they can construct water infrastructures such as charcoal dams to store water for the livestock, especially during the dry season when the same is scarce. The community development officers need to promote the formation of savings and credit societies (SACCOS and Village Cooperative Banks (VIKOBA) as membership in these have been observed to help households pay for the water required by their livestock. In addition, they should promote households diversification of livelihoods as this will increase their incomes hence, the ability to pay for the water needed by households and livestock. The government should subsidize the materials required by pastoralists in the construction of charco dams as this will allow the pastoralists to have the required access to water for their livestock. Lastly, agricultural financial institutions and commercial banks in Tanzania should provide credit to pastoralists so that they can also invest in draught powered equipment and the tools used in fetching water for domestic use, calves, lambs, and sick livestock.

References

Abubakar, I.R. (2019). Factors influencing household access to drinking water in Nigeria. Utilities Policy, 58 :40–51.

Adicha, A. Mada, M. (2020). Agro Pastoralists Perception and Willingness to Participate in Water Harvesting Practices in South Omo Zone, Southern Ethiopia. *American Journal of Agriculture and Forestry,* 8(5): 224-234.

Aganga, A.A. and Tsopito, C.M. (1995). Improving draft animal power technologies'

utilisation in Botswana. Paper presented at the 21st workshop of the SARCCUS (Southern African Regional Council for Conservation and Utilisation of Soils) Subcommittee for Agricultural Engineering held 5-9 June 1995, Gaborone, Botswana.

Agbadi, P. Darkwah, E. and Kenney, P.L. (2019). A Multilevel Analysis of Regressors of Access to Improved Drinking Water and Sanitation Facilities in Ghana. *Journal of Environmental and Public Health,* 1-11.

Aikowe, J.O. and Mazancová, J. (2021). Barriers to Water Access in Rural Communities: Examining the Factors Influencing Water Source Choice. Water, 13 (2755):1-24.

Akoteyon, I.S. (2019). Factors affecting household access to water supply in residential areas in parts of Lagos metropolis, Nige¬ria. Bulletin of Geography Socio-economic Series, 43(43), 7-24.

Awinia, C.S. (2020). The Sociology of Intra-African Pastoralist Migration: The Case of Tanzania. Frontier Sociology, 5: 1-10.

Babbie, E.R. (1990). Survey Research Method. Second Edition. Wardsworth Publishing Company, Belton, California.

Balfour, N., Obando, J. and Gohil, D. (2019). Dimensions of water insecurity in pastoralist households in Kenya. Waterlines, 39 (1): 24−43.

Beede, D.K. (2012). What will our ruminants drink? Animal Frontier, 2(2):36–43.

Bunker, S. (1985). Under developing the Amazon. Chicago: University of Illinois Press. 279pp.

Cassivi, A., Johnston, R., Waygood, E.O.D. and Dorea, C.C. (2018). Access to drinking water: time matters. *Journal of Water and Health,* 16 (4): 1-6.

Clark, V.L.P. and Ivankova, T. (2016). Mixed Method Research: A Guide to the field. Thousand Oaks, CA: Sage Publications.

Daly, S., Lowe, J., Hornsby, G. and Harris, A. (2021). Multiple water source use in low- and middle-income countries: a systematic review. *Journal of Water and Health,* 19(3): 370-392.

de Glanville, W.A., Davis, A., Allan, K.J., Buza, J., Claxton, J.R., Crump, J.A., Holliday, J. E.B., Johnson, P.C.D., Yoder, T.J., Sharp, S. and Cleaveland, S. (2020). Classification and characterisation of livestock production systems in northern Tanzania. PLoS ONE, 15(12):1-25.

Dettori, J.R. and Norvell, D.C. (2018). The Anatomy of Data. *Global Spine Journal,* 8(3):311-313.

Deutsch, L., Falkenmark, M., Gordon, L., Rockstrom, J. and Folke, C. (2010). Water-mediated ecological consequences of intensification and expansion of livestock production. In: Steinfeld H, Mooney H, Schneider F, Neville L.E, editors. Livestock in a Changing Landscape. Island Press, London, UK: Volume: 1 Drivers, Consequences and Responses. 97–110.

Djordjević-Milošević, S., and Milovanović, J. (2019). Pastoralism: Indigenous Way of Mitigating Climate and Poverty Risk. Zero Hunger, 1–12.

Dungumaro, E.W. (2007). Socioeconomic differentials and availability of domestic water in South Africa. Physics and Chemistry of the Earth, 32 :1141–1147.

Falanta, E.M. and Bengesi, K.M.K. (2018). Druers and consequences of recurrent conflict between farmers and pastoralists in Kilosa and Mvomero Districts, Tanzania. *Journal of Sustainable Development,* 11 (4):13-26.

Gebremedhin, G., Qiuhong, T., Siao, S., Zhongwei, H., Xuejun, Z. and Xingcai, L. (2019). Droughts in East Africa: Causes, impacts and resilience. Earth-Science Reviews, 193:146–161.

Gebremichael, S. G., Yismaw, E., Tsegaw, B. D. and Shibeshi, A. D. (2021) Determinants of water source use, quality of water, sanitation and hygiene perceptions among urban households in North- West Ethiopia: A cross-sectional study. PLoS ONE, 16(4):1-20.

Gettel, G., Muhadia, C. and Ericksen, P. (2019). Livestock and water in developing countries. ILRI Discussion Paper 38. Nairobi, Kenya: ILRI. 11pp.

Gomez, M., Perdiguero, J. and Sanz, A. (2019). Socioeconomic Factors Affecting Water Access in Rural Areas of Low and Middle

Income Countries. Water, 11(202):1-21.

Green, C., Duan, N., Gibbons, R., Hoagwood, K., Palinkas, L. and Wisdom, J. (2015). Approaches to mixed methods dissemination and implementation research: Methods, strengths, caveats, and opportunities. Administration and Policy in Mental Health and Mental Health Services Research, 42:508–523.

Hair, J.F. Jr., Black, W.C., Babin, B.J., Anderson, R.E. andTatham, R.L. (2010). Multivariate Data Analysis. 7th ed. New Jersey: Prentice-Hall International Inc.760pp.

Hamilton, S.H., Merritt, W.S., Das, M., Rahman, M.W., Bhuiya, S.S., Carter, L. and Syme, G.J. (2020). Integrated assessment how does it help unpack water access by marginalized farmers? Water, 12(12):1–22.

Hemmert, G.A.J. Schons, L.M. Wieseke, J. and Schimmelpfennig, H. (2016). Log-likelihood-based Pseudo-R^2 in Logistic Regression. Sociological Methods and Research, 47(3):507–531.

Ho, E.W., Strohmeier-Breuning, S., Rossanese, M., Charron, D., Pennise, D. and Graham, J.P., (2021). Diverse Health, Gender and Economic Impacts from Domestic Transport of Water and Solid Fuel: A Systematic Review. *International Journal of Environmental Research and Public Health,* 18 (10355):1-25.

Hodgson, G.M. (2017). Introduction to the Douglass C. North memorial issue. *Journal of Institutional Economics,* 13(1): 1–23.

Holechek, J.L., Pieper, R.D. and Herbel, C.H. (1998) Range Management: Principles and Practices. Prentice Hall, Upper Saddle River. 664pp.

Iteba, J.O., Hein, T., Singer, G.A. and Masese, F.O. (2021). Livestock as vectors of organic matter and nutrient loading in aquatic ecosystems in African savannas. PloS one, 16(9): 1-24.

Jiggins, J. and Hunter, G. (1979). Institutions and Culture: Problems of Criteria for Rural and Agricultural Development Projects. In: Institutions Management and Agricultural Development (Edited by Bottrall, A. Howell, J. and Sandford, S.) Overseas Development Institute London. Pp. 1-7.

Kahimba, J. and Niboye, E.P. (2019). Water-Use Permits and Water Accessibility for Livestock in Tanzania. *Tanzania Journal of Development Studies,* 17(2): 44-55.

Kaswamila, A. (2009). Human-wildlife conflicts in Monduli district, Tanzania. *International Journal of Biodiversity Science and Management,* 5(4): 199–207.

Kattel, R.R. (2015). Rainwater Harvesting and Rural Livelihoods in Nepal, SANDEE Working Paper No 102-115. 23pp.

Kayser, G.L., Moriarty, P., Fonseca, C. and Bartram, J. (2013). Domestic Water Service Delivery Indicators and Frameworks for Monitoring, Evaluation, Policy and Planning: A Review, *International Journal of Environmental Research and Public Health,* 10: 4812-4835.

Kimaro, E.G. Mor, S.M. and Toribio, J.A.L.M.L. (2018). Climate Change Perception and Impacts on Cattle Production in Pastoral Communities of Northern Tanzania. Pastoralism, 8(1): 1–16.

King, J.M. (1979). Game domestication for animal production in Kenya: Field studies of the body water turnover of game and livestock. *Journal of Agricultural Science,* 93: 71-79.

Koch, J. (2008). Perspectives on Access to and Management of Natural resources. DIIS Working paper 8. 30pp.

Koletsi, D. and Pandis, N. (2018). Research Design: Ordinal logistic regression. *American Journal of Orthodontics and Dentofacial Orthopedics,* 153:157-158.

Magita, S.Y. and Sangeda, A.Z. (2017). Effects of climate stress to pastoral communities in Tanzania: A Case of Mvomero District. Livestock Research for Rural Development, 29 (8):1-7.

Mahoo, H., Simukanga, L. and Kashaga, R. (2015). Water Resources Management In Tanzania: Identifying Research Gaps And Needs And Recommendations For A Research Agenda. *Tanzania Journal of Agricultural Sciences,* 14(1): 57–77.

Matimbwa, H. and Mwalimu, W. (2019). Factors Leading to Conflicts Between Farmers and Pastoralists in Tanzania: Evidence From Kambala Village in Morogoro. *Journal*

of Business Management and Economic Research, 3(8):26–39.

Mattee, A.Z. and Shem. M. (2006). Ambivalence and contradiction. A Review of the policy environment in Tanzania in relation to pastoralism. Issue paper no 140. International Institute for Environment and Development London, UK. 40pp.

Mengistu, A.T. (2021). How Small-Scale Farmers Understand Rain Water Harvesting Technology? Evidence from Northern Ethiopia. *Scientific World Journal,* 10 (1155):1-7.

Mishra, L. (2016). Focus Group Discussion in Qualitative Research. Techno Learn, 6 (1): 1-5.

Muganda, L. and Croney, C. (2019). Factors Affecting Perceptions of Animal Welfare in Developing Countries. [https://www.extension.purdue.edu/extmedia/AS/AS-650-W.pdf] Site visited on 6/4/2022.

Mung'ong'o, H.G., Mbonile, M.J. and Maganga, F.P. (2019). Innovative pathways for enhancing climate change and variability resilience among agro-pastoral communities in semi-arid areas of Kiteto and Kilindi Districts, Tanzania. *African Journal of Environmental Science and Technology,* 13(5): 201–219.

Mwasame, D.B. (2020). Analysis of the Socio-economic contribution of Donkey Ownership and use to household livelihoods in Kiambu County Kenya, Unpublished thesis for Award of MSc of the University of Nairobi, Nairobi Kenya. 71pp.

Ngarava, S., Zhou, L. and Monde, N. (2019). Gendered Water Insecurity: A Structural Equation Approach for Female Headed Households in South Africa. Water, 11 (2491):1-19.

Njuki, J., Poole, J., Johnson, N., Baltenweck, I., Pali, P., Lokman, Z. and Mburu, S. (2011). Gender, Livestock and Livelihood Indicators. International Livestock Research Institute, Nairobi. 40pp.

North, D.C. (1991). Institutions. *Journal of Economic Perspective,* 5(1):97–112.

Nounkeu, C.D., Metapi, Y.D., Ouabo, F.K., Kamguem, A.S.T., Nono, B., Azza, N., Leumeni, P., Nguefack-Tsague, G., Todem, D., Dharod, J.M. and Kuate, D. (2022). PLOS Water, 1(8): 1-15.

Oksen, P. and Favre, L. (2020). Global Challenges in Focus Innovative Technology in the Water, Sanitation and Hygiene (WASH) Sector. World Intellectual Property Organization.

Onesmo, O.P. (2016). An Assessment of the Tanzania Livestock Policy of 2006 And It Impact On the Livelihoods of Pastoral Communities in Tanzania. Unpublished Dissertation for Award of MA at University of Dar es Salaam, Dar es Salaam, Tanzania. 110pp.

Opiyo, F.E.O., Mureithi, S.M. and Ngugi, R.K. (2011). The Influence of Water Availability on Pastoralist's Resource Use in Mwingi and Kitui Districts in Kenya. *Journal of Human Ecology,* 35(1): 43–52.

Pallas, P. (1986) Water for animals. AGL/MISC/4/85. Land and Water Development Division. Food and Agriculture Organization, Rome. 82pp.

Pelletier, N. and Tyedmers, P. (2010). Forecasting potential global environmental costs of livestock production 2000-2050. PNAS, 107(43): 18371–18374.

Ribot, J. and Peluso, N. (2003). A theory of access. Rural Sociology, 68(2): 153-181.

Rweyemamu, D.R. (2019). Understanding the Factors leading to Conflicts among Agropastoralist and Farming Communities in Morogoro region, Tanzania, and their implications for wellbeing. PhD dissertation, Lincoln University.

Saladi, J.A. and Salehe, F.S. (2017). Assessment of Water Supply and Its Implications on Household Income in Kabuku Ndani Ward, Handeni District, Tanzania. *Asian Journal of Environment and Ecology,* 2(1): 1-26.

Salkind, N.J. (2010). Encyclopedia of Research Design. Retrieved from [https://methods.sagepub.com/Reference/encyc-of-research-design 20/07/2021] Site visited on 20/11/2022.

Sani, Y. and Scholz, M. (2022). Gemder and Other vulnerabilities to water-energy accessibility in Rural Households of Katsina State, Northern Nigeria. Sustainability, 14(7499):1-18.

Simelane, M.S., Shongwe, M.C., Vermaak, K. and Zwane, E. (2020). Determinants of Households' Access to Improved Drinking Water Sources: A Secondary Analysis of Eswatini 2010 and 2014 Multiple Indicator Cluster Surveys. Advances in Public Health, 6758513: 1-9.

Starkey, P. and Starkey M, 1997. Regional and world trends in donkey populations. pp 14-25 in Starkey P (ed) Donkey power benefits. Workshop Reader Volume 1. Prepared for workshop on Improving donkey utilisation and management held 5-9 May 1997, Debre Zeit, Ethiopia.

Stewart, D.W., Shamdasani, P.N. and Rook, D.W. (2002). Focus Groups: Theory and Practice. Sage Publications: Thousand Oak, CA, 42-43.

Swai, E.S. and Bwanga, S.J.R. (2008) Donkey keeping in northern Tanzania: socio-economic roles and reported husbandry and health constraints. Livestock Research for Rural Development, 20 (67). http://www.lrrd.org/lrrd20/5/swai20067.htm Site was visited on 16/4/2023.

Thompson, J., Porras, I.T., Katui-Katua, M., Mujwahuzi, M.R. and Tumwine, J.J. (2003). Drawers of water II: Assessing change in domestic water use in East Africa. Waterlines, 22(1): 22-25.

Tofu, D.A., Fana, C., Dilbato, T., Dirbaba, N. B. and Tesso, G. (2023). Pastoralists' and agro-pastoralists' livelihood resilience to climate change-induced risks in the Borana zone, south Ethiopia: Using resilience index measurement approach. Pastoralism, 13(4): 1-14.

URT, United Republic of Tanzania (2010). Ministry of Livestock and Fisheries Development Livestock Sector Development Strategy 2010, Dar es Salaam, Tanzania. 79pp.

URT, United Republic of Tanzania, (2002). National Water policy July, 2002. Dar es Salaam, Tanzania. 49pp.

van Eeden, A., Mehta, L. and van Koppen, B. (2016). Whose waters? Large-scale agricultural development and water grabbing in the Wami-Ruvu River Basin, Tanzania. Water Alternatives, 9(3): 608-626.

Vinti, S. (2020). A Generalized Summation Formula. Math LAB Journal, 6:62-64.

Wakchaure, R., Ganguly, S. and Praveen, P. K. (2015). Role of water in livestock. The Recent Advances in Academic Science Journal, 1:56-60.

Wang, H., Xie, J. and Li, H. (2010). Water pricing with household surveys: A study of acceptability and willingness to pay in Chongqing, China. China Economic Review, 21:136-149.

World Health Organization (WHO) and UNICEF, (2017). Progress on Drinking Water, Sanitation and Hygiene: 2017 Update and SDG Baselines. 108pp.

World Water Assessment Programme (WWAP) (2016). The United Nations World Water Development Report 2016: Water and Jobs. Paris: United Nations Educational, Scientific and Cultural Organization. Available from http://unesdoc.unesco.org/images/0024/002439/243938e.pdf.

Yamane, T. (1967). Statistics: An Introductory Analysis, 2nd Ed. New York: Harper and Row. 919pp.

Yator, S. and Kwasira, J. (2020). Post Covid-19 Online Business Strategies by Small Scale Entrepreneurs in Malaysia. *International Journal of Academic Research in Business and Social Sciences,* 10(10):341-359.

Young, S.L., Bethancourt, H.J., Ritter, Z.R. and Frongillo, E.A. (2022). Estimating national, demographic, and socioeconomic disparities in water insecurity experiences in low-income and middle-income countries in 2020–21: a cross-sectional, observational study using nationally representative survey data. Lancet Planet Health, 6: 880–891.