



Influence of Water Access for Livestock on the Livelihood Strategies of Agro-Pastoralists in Monduli District, Tanzania

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Abstract: During the dry season, pastoralists in Monduli District experienced water shortages for livestock, which in turn caused changes in the pastoral production system. This study investigated the influence of water access for livestock on pastoralist's livelihood strategies in Monduli District, Tanzania. A cross-sectional research design was adopted to collect data at a single point in time. A semi-structured questionnaire was administered to collect quantitative and qualitative data from the 367 randomly selected respondents in the two selected wards. Focus Group Discussions and Key Informants Interviews were utilized to collect qualitative data. Statistical Package for Social Science was used to analyse quantitative data. Descriptive statistics including frequency counts and percentages; and inferential statistics including chi-square and multinomial logistic regression models were used to analyse the influence of the level of water access for livestock by pastoralists on the choice of livelihood strategies. Qualitative data was analysed using content analysis. The findings of the study show that low levels of water access for livestock compelled the households to diversify into farming and off-farming livelihood strategies. In that perspective, the medium water access compelled the pastoralist households to diversify into farming activities while maintaining high water access for the livestock reference category. In addition, the findings of the study show that household capital does not influence the diversification of Livelihood Strategies. Based on the findings, the level of water access for livestock appeared to be the most important factor that influenced the pastoralists' livelihood strategies in semi-arid settings of the study area. The Tanzanian government should devise plans and implement specific water development projects for livestock to improve the level of water access for livestock and, as a result, improve their livelihood.

Keywords: Pastoralists, livelihood strategies, water access, semi-arid settings, livestock production

1. Background Information

Various global studies have emphasized the crucial role of water access in sustaining livestock production (Gettel *et al.*, 2019; Heinke *et al.*, 2020; Paul *et al.*, 2021). The availability and reliability of water sources have a direct impact on livestock production, which serves as the backbone of pastoral economies (De Haan, 2016; Pankaj *et al.*, 2021; Habte *et al.*, 2022). Furthermore, scientific studies in Sub-Saharan Africa have highlighted pastoral communities' vulnerability to climate change over time (Menghistu *et al.*, 2020; Kimaro *et al.*, 2018; Abraham and Mekuyie, 2022). Additionally, these studies shed light on the adaptive strategies against water scarcity for livestock adopted by pastoralists, including mobility, water management techniques, and engagement in off-farm activities (Mfinanga *et al.*, 2023; Basupi *et al.*, 2019; Sulieman *et al.*, 2023).

Neo-liberalism emphasizes market forces, privatization and individual decision-making for economic growth (Springer *et al.*, 2016; Birch, 2015). Within this context, access to water has often been approached through market-oriented mechanisms, such as water pricing, trade liberalization, and water user associations (Bakker, 2014). Neo-liberal proponents argue that market-based approaches incentivize efficient water use, encourage investment in water infrastructure, and promote economic development (Boelens *et al.*, 2018; Hartwig, 2020). However, various scientific studies in Sub-Saharan Africa have shown that neo-liberal policies may not have properly addressed the socio-cultural and ecological aspects of water access for pastoralists (Basupi *et al.*, 2017; Mathekganye *et al.*, 2019). On the other hand, the implementation of neoliberal policies relating to



livestock water access in Sub-Saharan Africa, particularly Tanzania, did not provide the desired results in terms of improving livestock productivity and livelihood in semi-arid areas.

Chambers and Conway (1991) contend that a livelihood consists of people, their competencies and their way of living such as assets, food and income. In addition, Scoones, (1998) pointed out that under a given context such as socio-economic, agroecology, policy setting and politics, the combination of different livelihood resources accompanied by household assets compel individuals or households to make their choices of livelihood strategies to achieve livelihood outcomes. In semi-arid areas, pastoralists are endowed with physical assets such as livestock, water, as well as land which determine their livelihoods in one way or another.

When it comes to water supply and access in Tanzania, human consumption is given priority over other economic activities such as livestock keeping Hyandye *et al.* (2018). Literature shows the lack of social services provision such as water supply for livestock by governments to the pastoralists (Mati *et al.*, 2006; Randall, 2015). However, government initiatives emphasize the modernization of livestock production through ranch systems and sedentarization of pastoralists (Mattee and Shem, 2006; PINGO, 2016).

Livestock production is a crucial component of the livelihood strategies of many households in semi-arid areas in Tanzania (Nkedianye *et al.*, 2019; Yanda *et al.*, 2015; Cosmas *et al.*, 2022). However, the issue of the influence of water access for livestock on livelihood strategies is a topic not well investigated in these areas. While some studies have examined factors influencing water access for livestock in semi-arid areas, particularly Monduli District, Arusha Region Tanzania (Mfinanga *et al.*, 2023; Ngasala *et al.*, 2018), and the poor availability of water and pastures has been identified as the single most important factor constraining productivity of livestock in Tanzania (Mudavad *et al.*, 2020; de Glanville *et al.*, 2020; Turner and Schlecht, 2019), there is still a research gap in understanding the influence of water access for livestock on livelihood strategies in semi-arid areas in Tanzania. This gap presents an opportunity for further research to investigate the influence of water access for livestock on the livelihood strategies of pastoralist households in these areas. Understanding the influence of livestock water access on pastoralists' livelihood strategies is essential because it is a wake-up call to the Tanzania government and other development partners to design and implement development projects that improve alternative livelihood strategies intending to ensure water access for livestock.

1.1 Theoretical Framework

This study is guided by the Sustainable Livelihood Framework (SLF) proposed by the United Kingdom's Department for International Development (DFID) (DFID, 1999). The SLF was deemed useful for this study because it is an effective tool for estimating livelihood research (Mwenda and Turpin 2016). The framework links inputs (capital including social, physical, financial, natural and human) and outputs (livelihood strategies) under the influence of policies, institutions and structures in turn to livelihood outcomes such as household income (Lyatuu and Urassa, 2015). Therefore, this study focuses on the links between inputs such as household capital and water access for livestock; and the output which includes livelihood strategies practised by households. Previous studies show that the capacity of a household to diversify into meaningful livelihood strategies depends on the combination of individual or household assets (Small, 2007; Dinku, 2018). Nevertheless, Muyanga *et al.* (2013) assert that assets have synergies; this implies that improving one asset can raise the value of another asset. Similarly, Dinku (2018) asserts that livelihood diversification strategies are location-specific.

1.2 Conceptual framework

The conceptualization of this study is based on an assumption that the household capital and the level of water access for livestock influence the pastoralists' households' livelihood strategies. This assumption is supported by Small (2007) who contends that the ability of a household to pursue a meaningful diversity of LS depends on its assets endowment and its ability to combine them. In this study, the variable of institutions was applied because Lyatuu and Urasa (2015), contend that having an abundant amount of resources (capital) enables an individual or a household to diversify into different livelihood strategies. Furthermore, Nasrnia and Ashktorab, (2021) claim that the Sustainable Livelihood Framework in particular circumstances allows households or individuals to combine assets or to use a group of assets for livelihoods without the presence of institutions. Water access for livestock in this study is categorized into high, medium and low. It was derived from five indicators namely: distance walked by livestock to the water point, the time spent in watering livestock, the type of water source used by livestock, the amount of income spent by households on water services and the multiple uses of water sources for livestock. In this study, high or medium water access for livestock is considered to have enhanced livestock production and reduced household water insecurity. In addition, it has allowed a household to diversify their economic activities such as farming and off-farm activities. Similarly, low water access for livestock is assumed to have motivated an individual to seek other alternative means of production such as farming and off-farm income-generating activities to supplement the water charges for livestock.

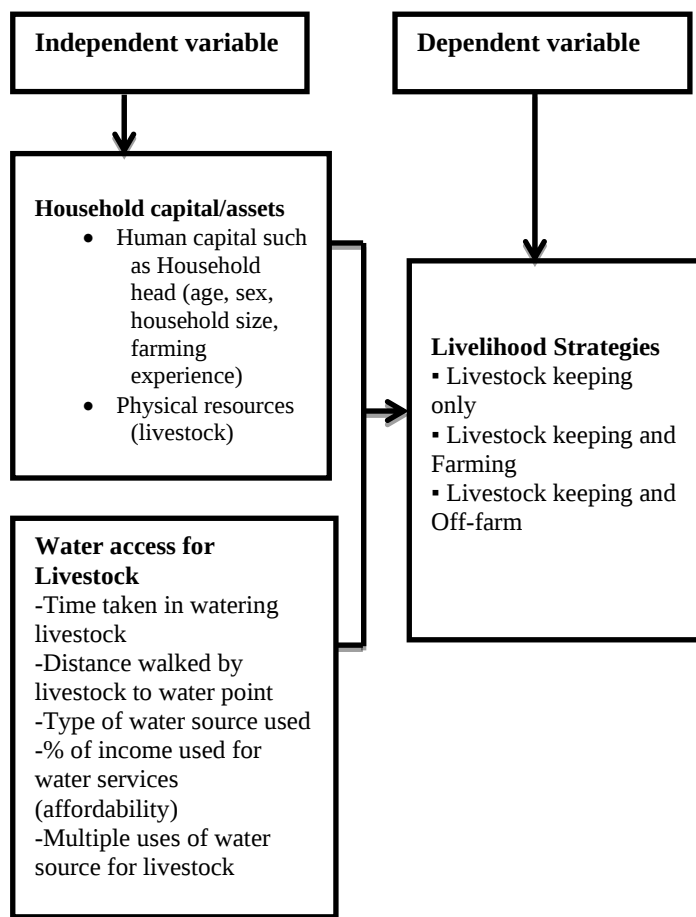


Figure 1: Conceptual framework of the study adapted from (DFID, 1999).

In this study, livestock keeping is considered to be the main economic activity supporting LS (Homewood *et al.*, 2006) among other activities such as farming and off-farm income-generating activities. Nonetheless, Djido and Shiferaw (2018) assert that the analysis of livelihood strategies depends on the most common groups of LS found in a particular area. Moreover, this study assumes that the choice of livelihood strategies depends on a combination of household assets such as physical assets (livestock), human capital (age of household head, sex of household head, and education of the household head, livestock keeping experience of the household head and household size, as well as the access to natural capital namely water access for livestock). Therefore, this conceptual framework aims to show the influence of water access for livestock on livelihood strategies through household capital.

2.0 Methodology

2.1 The Study Area

Monduli District is one of the seven districts of the Arusha Region of Tanzania. It is located in the northeastern part of the country. The district has two ecological zones, the highland ecological zone characterized by a humid climate and annual rainfall ranging between 500mm and 900mm;

and the lowland ecological zone with a semi-arid climate and rainfall ranging between 200mm and 600mm (Msoffe *et al.*, 2011). This study was carried out in Monduli District because 70% of its area is low land ecological zone with a semi-arid climate characterized by drought and shortage of water for livestock (Msoffe *et al.*, 2011; Kimaro *et al.*, 2018) and livestock keeping is the main economic activity in the area (Homewood *et al.*, 2006).

The study was conducted purposively in Makuyuni and Moita Wards. These two wards were selected purposively because they are prominent livestock-keeping activities areas and they are located in semi-arid areas (Kimaro *et al.*, 2018). All seven villages in selected wards namely Moita Kipoki, Moita Kilorit, Moita Bwawani and Kilimatinde from Moita Ward and Mbuyuni, Naiti and Makuyuni from Makuyuni Ward were included in the study.

2.2 Research Design, Sampling Techniques and Sample Size

Cross-sectional research design was used in this study because it allows a collection of both qualitative and quantitative data at one point in time (Wang and Zhenshun, 2020; Creswell, 2014). The target population was heads of households whose major economic activity was livestock keeping. The respondents were chosen randomly from a list of pastoralist households based on the population proportions of each village. Based on the total household population of 4390. The sample size was computed by using Yamane's (1967) formula because it is applicable for use in determining optimal sample size for both continuous and categorical variables at all levels of confidence (Adam, 2020). The formula elaborated below in equation (i) as follows:

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

Where N=total households population, e is the level of precision (sampling error) the study used 5% and n is the sample size of the study. The sample size of each village (Table 1) was computed by using the proportional sampling formula by Salkind (2010) as elaborated in equation (ii).

$$\text{Equation (ii)} \\ n_b = \frac{N_b}{N} \times n \dots \dots \dots (ii)$$

Where n_b = sample size of the village N_b = Total number of households in the village, N is the total household population, n = total sample size of the study.



Table 1: Sample size composition of each village in the study area

Ward	Village	Total number of households in each village	Sample size
Makuyuni	Moita Kipok	470	39
	Moita Kilorit	533	45
	Moita	754	63
	Bwawani		
	Kilimatinde	453	38
Makuyuni	Naiti	465	39
	Mbuyuni	556	46
	Makuyuni	1159	97

A semi-structured questionnaire was administered to collect quantitative and qualitative data on the influence of water access for livestock and household capital (assets) on household choice of livelihood strategies. Qualitative data were collected by using checklists through FGD, Key Informants Interviews (KIIs) and observations. Nine (9) Focus Group Discussions (FGD) were held, with four men alone FGD held in the Moita Ward and three men only FGD held in the Makuyuni Ward. Given that women speak less when mixing with males during FGD (Stewart *et al.*, 2002), each ward had one FGD comprised entirely of women, for a total of two female FGDs. Each FGD included 6-10 pastoralists, which George (2016) considers to be an adequate number for a FGD. Key Informants Interviews were conducted with sixteen key informants including two extension officers, two traditional leaders, three rural water and sanitation authority officers, two ward executive officers and seven village executive officers. The pre-testing took place outside of the research locations, in Esilalei village, in Esilalei ward, in Monduli District, with 30 randomly selected and questioned respondents. Secondary data was collected from unpublished and published documents which include: reports from different sources like the Ministry of Water and Irrigation, Ministry of Livestock and Fisheries, Monduli District RUWASA Office, journals, books, theses, Sokoine University Library and Government Policy documents.

2.3 Data Analysis

To determine the influence of water access for livestock on (LS), a pastoralist was defined as diversified into various LS if he or she engages in any of the strategies namely livestock keeping only, livestock keeping and farming, livestock keeping and off-farm income generating activities. The independent variables were both continuous and discrete.

The independent variables are as follows:

- Water access (high, medium and low). The level of water access for livestock (high, medium, low) during drought season was measured through Water Access for Livestock Index Score (WALIS) using five criteria including (1) multiple uses of water (1=water source has multiple uses, 0=otherwise), (2) types of water source used (1=improved, 0=unimproved), (3)

distance to water sources (2=0-5km, 1= 6km - 10km, 0= >10km), (4) time taken in watering livestock (2= ≤5hours, 1 = 6-10 hours, 0=>10hours), and (5) affordability (if a household used household income of 3% or more, on water access for livestock and other uses = 0 not affordable 1=affordable if household income used on water charges were less or equal to 3%). Then water access for livestock index score (WALIS) (high, medium, low) was computed by using Vinti's (2020) generalized summation formula below;

Equation (iii)

$$WALIS = \sum_{i=1}^n xi \text{ (Vinti, 2020)(iii)}$$

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 to water sources, 4= time taken in watering, 5=affordability). n=Total number of indicators i.e. 5, Xi=Score of the respondent on ith indicator. Summation of scores for each respondent derived from the five dimensions of water access for livestock was carried out with the highest and lowest scores being 8 and 0, respectively. The respondents were then categorized into high water access (scores ranging from ≥ 5), medium water access (3 to <5) and low water access (0 to ≤3).

- Livestock-keeping experience (Human capital) measured the number of years respondents have been keeping livestock.
- The age of a pastoralist household head (human capital) was measured as respondent age in years.
- Sex was measured as being male or female (human capital) coded 1=male 0=female).
- Household size (human capital) was measured as the number of people living in a household (number).
- Livestock owned by household head (physical capital) measured in Tropical Livestock Unit (TLU). Tropical Livestock Unit (TLU) refers to livestock units owned by households; in Sub-Saharan Africa, one TLU is equivalent to one mature cow weighing 250 kg. (Njuki *et al.*, 2011). The following units in Table 2 are used to compute TLU by using Njuki (2011) formula as presented in equation (iv).

Equation (iv)



$$\text{Total livestock holding} = \sum_{i=1}^n \text{TLUi} \dots\dots\dots (iv)$$

Where

n =number of species/type, TLUi =TLU for species/type i and i=species type.

Table 2: Exchange Factor of Livestock Type into TLU

Livestock type	TLU
Dry cow	1.0
Goat	0.20
Mature cow	1.0
Sheep	0.20
Oxen	1.42
Donkey	0.80
Heifer	0.78
Poultry	0.04
Bull	1.20
Calve	0.41 (considered as average of male=0.38 and female =0.43)

Source: Njuki *et al.* (2011). Key: 1 TLU=1 mature cow of 250kg.

The collected quantitative data were coded and entered in SPSS version 20 for analysis. First; the study employed cross-tabulation whereby frequency counts and percentages are used to describe the linkage between household choice of livelihood strategies and the level of water access for livestock. Additionally, the Chi-square test is used to examine the relationship between livelihood strategies and the level of water access for livestock. Furthermore, the Multinomial Logistic Regression Model equation (v) by Agresti and Finlay (2009) was used to determine the influence of water access for livestock on household choice of livelihood strategies. MLRM was preferred because it's the best model for predicting non-ordinal multiple categorical outcomes with more than two nominal categorical variables (Kwak and Clayton-Matthews, 2002). Equation (v)

$$P(Y) = \frac{e^{\alpha + \beta_1 X_1 + \dots + \beta_k X_k}}{1 + e^{\alpha + \beta_1 X_1 + \dots + \beta_k X_k}} \dots\dots\dots (v)$$

Where

P(Y) = the likelihood of the successful alternative occurring (in this study a success is Livelihood strategies 1=livestock only 2: livestock keeping and off-farm 3: livestock keeping and farming.

e= the natural log, α = the intercept of the equation, β_1 to β_k = coefficients of the predictor variables and X_1 to X_k = predictor variables entered in the regression model including the level of water access for livestock variables (High, medium, and Low) and selected households' capital (assets). The Exp (β) is the beta exponential or odds ratio. The regression coefficient used for this analysis was β coefficient (standardized or referred to as beta), which refers to the amount of change in the dependent variable (symbolized as Y), based on a single unit change in the independent

variables (symbolized as X) (Howell, 2002). Consistent with Turner, (2020) and Belsley *et al.* (1980), multicollinearity was tested using Variance Inflation Factor (VIF) before estimation of the model. Pearson chi-square and likelihood ratio tests were used to measure the goodness of fit of the model.

Content analysis was used to analyse qualitative data collected from semi-structured questionnaires and FGDs. Content analysis involves the transcription of recorded information into text, then categorising and coding the data into themes and finally generalising and interpreting the theme about the phenomena based on available literature.

3.0 Results and Discussion

This section presents the results and discussion of the influence of water access for livestock on the choice of household Livelihood Strategies (LS). Results and discussion are covered in sections which include: levels of water access for livestock namely high, medium and low levels of water access for livestock. On the other hand livelihood strategies considered are livestock keeping only, combined livestock keeping and off-farm activities and livestock keeping and farming. Each level of water access for livestock by household is investigated separately by using chi-square to examine its influence on household choice of livelihood strategies. Moreover, the multinomial logistic regression model is used to examine the influence of water access for livestock on pastoralist's choice of livelihood strategies.

3.1 The influence of water access for livestock on the household choice of livelihood strategies

The influence of levels of water access for livestock namely high water access, medium and low levels in this study is investigated respectively. In this study, the results in Table 3 indicate that out of 367 interviewed respondents, the majority 225 (61.3%) diversified into livestock keeping and off-farm activities followed by 110 (30%) livestock keeping and farming and the least 32 (8.7%) engaged only with livestock keeping. Additionally, the highest percentage of respondents engaged with livestock only 81.3% have a low level of water access for livestock while none of them have high water access for livestock. This implies that the respondents who only keep livestock are vulnerable to their livestock not having enough access to water. However, Chi-square results ($2=1.076$, $df=2$, $p=0.585$) show that there is no significant difference between respondents who exclusively raise livestock and those who have low access to water for their livestock. Additionally, past research in Tanzania demonstrates that pastoralists in semi-arid areas struggle with inadequate water supply for livestock (Kimaro *et al.*, 2018; Saruni, 2018).

Regarding respondents engaged with livestock keeping and farming the results in Table 3 show that out of 367 interviewed respondents 30% diversified into livestock

keeping and farming. Furthermore, the highest percentage of respondents in this livelihood strategy 76.9% have a low level of water access for livestock while a few 2.7% have a high level of water access for livestock. Chi-square results ($\chi^2=0.315$, $df=2$, $p=0.854$) show that there is no significant difference between respondents diversified into farming and the level of water access for livestock. These findings differ from that of Suleiman *et al.* (2017) who reported that livelihood diversification among pastoralists depends on water access.

On the other hand the results in Table 3 indicate that out of 367 interviewed respondents 61.3% diversified into livestock keeping and off-farm activities. Moreover, the highest percent of respondents diversified into livestock keeping and off-farm activities 73.6% have low level of water access while 23.6% have medium water access for livestock. This implies that a low level of water access for livestock serves as an incentive to engage in other non-livestock activities particularly off-farm income-generating activities as also revealed by Watete *et al.* (2016). Furthermore, the finding is contrary to that of Balfour *et al.* (2020) who revealed that livelihood strategy diversification among pastoralists does not influence any level of water access for livestock.

Table 3: Levels of Water Access for Livestock and Livelihood Strategies of Pastoralists

Livelihood strategies	Levels of Water access for livestock								Chi-square test		
	High		Medium		Low				χ^2	df	p
	n	%	n	%	n	%	n	%			
Livestock keeping only	32	8.7	0	0	6	18.8	26	81.3	1.076	2	0.585
Livestock keeping and farming	110	30	6	2.7	46	20.4	173	76.9	0.315	2	0.854
Livestock keeping and off-farm activities	225	61.3	3	2.7	26	23.6	81	73.6	0.614	2	0.736
TOTAL	367		9	2.5	78	21.3	280	76.3			

f =frequency, n =number of respondent, χ^2 =chi-square value, df =degree of freedom and p = p- value.

3.2 Model Results on the Influence of Water Access for Livestock on Livelihood Strategies

The study results in Table 4 indicate that low level of water access for livestock had positively and significantly influenced the choice of LS of livestock keeping and farming as compared to those practised livestock keeping only at (B =

2.458, $p=0.018$, odds ratio (EXP (B)) of 11.680). This indicates that respondents with low levels of water access for livestock were 11.680 times more likely to engage with livestock keeping and farming LS than practising livestock keeping only as compared to those with high water access. Furthermore, this result implies that a low level of water access for livestock increases the likelihood for households to diversify into livestock keeping and farming activities as compared to those with a high level of water access. It was further noted during FGDs at Naiti and Moita Kilorit villages that pastoralists with limited access to water for livestock were cultivating beans as a commercial crop to enhance household income and sustain livestock water supplies. These findings are similar to the response by the Livestock extension officer at Makuyuni Ward who said:

"...Pastoralists in Naiti, Makuyuni, and Mbuyuni villages grow beans as a business crop and maize as a food crop. Water sources for livestock become scarce and water charges rise during difficult times of the year, especially when free communal water sources dry up. Pastoralists with a small herd or those who do not want to sell their livestock pay water charges with money earned from the sale of beans ..."

This implies that pastoralists with limited water access for livestock engage in farming as an alternative Livelihood Strategy to meet livestock water charges during the dry season when water is scarce and water charges are high. Furthermore, the results indicate that low level of water access for livestock had a significant positive influence on the choice of combined LS of livestock keeping and off-farm activities as compared to those engaged with livestock keeping only, with $B = 3.336$ $p=0.001$, odds ratio of 28.112 at $p<0.05$ significant level (Table 4). This implies that respondents with low water access for livestock were 28.112 times more likely to engage with combined LS of livestock keeping and off-farm income activities rather than practising livestock keeping only as compared to those with high water access. In this regard, households with low levels of water access for livestock were likely to participate in combined LS of livestock keeping and off-farm activities.



Table 4: Results of Multinomial Regression Models on the Influence of WAL on LS

Predictor Factors	Livestock and farming				Livestock and off-farm				VIF
	B	Std. Error	Sig.	Exp (B)	B	Std. Error	Sig.	Exp (B)	
Intercept	0.538	1.007	0.593		0.244	1.094	0.824		
Livestock keeping experience	0.002	0.006	0.782	1.002	0.002	0.006	0.758	1.002	1.03
Herds size (TLU)	0.000	0.002	0.889	1.000	-0.001	0.002	0.558	0.999	1.61
Household size	-0.003	0.029	0.919	0.997	-0.057	0.042	0.176	0.944	1.53
Female	-1.752	0.000	0.982	0.173	18.658	0.000	0.346	1.268E8	1.01
Age	0.000	0.015	0.988	1.000	-0.007	0.017	0.696	0.994	1.12
Household Capital									
Medium water access	1.550	0.513	0.002*	4.712	0.147	0.599	0.806	1.158	1.32
Low water access	2.458	1.038	0.018*	11.680	3.336	1.046	0.001*	28.112	1.44

*Significant at 5% level, Pearson (Chi-Square=698.247; df=712; sig. = .637; Deviance (Chi-Square=554.775; df=712; sig.= 1.000, -2 Log Likelihood (Intercept Only=641.378, Final =554.775); Chi-square=86.602, df=16, sig. =0.000), Pseudo R-Square (Cox and Snell=0.210; Nagelkerke=0.255; McFadden=0.135). Note: Livestock only= Reference category, water access reference category= high access, Male =reference category.

During an interview with key informants, it was further revealed that engagement with off-farm activities serves as an alternative means of getting money for paying water

charges during drought seasons. This was common among pastoralists with limited water access for livestock. A traditional leader from Moita Ward confirmed that by saying:

"...During the wet season, which begins from December to June each year, some individuals migrate to cities in search of jobs. Many of them are youth. They engage in petty trade, selling traditional herbs, and the vast majority work as security guards. They did so early before the commencement of the dry season. Normally during dry season which begins in July and ends in November some individuals again migrate from urban to rural areas to take care of livestock after collection of funds from various jobs..."

This implies that households with low levels of water access for livestock and domestic use have to find alternative LS to generate income, particularly off-farm activities. The findings have several implications. Firstly, it emphasizes the significance of water access as a critical component impacting livestock keepers' livelihood choices. In locations where water is scarce, livestock keepers are forced to seek alternative income sources to support their families. They can avoid the hazards associated with just relying on livestock keeping by diversifying their economic activities, such as engaging in off-farm activities.

Second, the data highlight livestock keepers' adaptive tendency in response to environmental limits. Individuals and households in water-stressed areas must alter their livelihood practices to guarantee economic stability and resilience. Adoption of integrated livestock and off-farm operations is a proactive strategy for mitigating water scarcity and improving income sources.

Furthermore, the findings highlight the potential advantages of integrated or diverse livelihood methods. Households can increase their overall income and lessen their exposure to water scarcity for livestock and economic shocks by engaging in off-farm revenue activities in addition to livestock husbandry.

In addition, the results indicate that medium water access for livestock had a significant positive influence on the choice of LS of livestock keeping and farming as compared to the choice of livestock keeping only, with B =1.550, p=0.002, and odds ratio of 4.712 at p<0.05 significance level (Table 4). This indicates that respondents with medium water access for livestock were 4.712 times more likely to engage with a livelihood strategy of combined livestock and farming activities than practising only livestock keeping as compared to those with high water access. Similarly, this finding suggests that a medium level of water access for livestock increases the likelihood for households to diversify into farming activities. Pastoralists opted for the choice of adopting combined LS of livestock keeping and farming to secure household food security since they have average water access for livestock supporting livestock production.



These findings have two ramifications. First, they emphasize the importance of water access in shaping livestock keepers' livelihood choices. Livestock keepers with moderate water availability are more likely to take advantage of the option to engage in farming activities in addition to livestock keeping. This suggests that having access to a sufficient water supply allows households to expand their economic activity, making use of the potential benefits of both the livestock and farming sectors. Lastly, the findings offer insight into the ability of water access to foster agricultural diversity. Pastoralists with moderate water access are more inclined to take chances with farming activities, implying that water availability is a vital enabler for increasing agricultural production beyond livestock keeping. This diversification can result in more food diversity, better nutrition, and greater overall resistance to water scarcity for livestock. These findings are contrary to studies by Van Houweling *et al.* (2012) and Fielmua *et al.* (2019), which posit that limited water access influenced households to engage in off-farm activities. More contrarily, these findings differ from a study by Balfour *et al.* (2020) which reported that the level of water access for livestock does not influence the choice of livelihood strategies practised by pastoralist households in Kenya. The overall findings of this study confirm that the average level of water access for livestock leads to moderate diversification of LS to cope with the water supply for livestock.

4.0 Conclusion and Recommendations

Livestock keeping only and combined livestock keeping and farming, livestock keeping and off-farm activities are the main choice of livelihood strategies (LS) among pastoralists in the study area. The levels of water access for livestock are the main factors that influence household choice of LS in the study area. The lower the level of water access for livestock by pastoralists the more the household diversified into farming and off-farm income-generating activities. Pastoralists with an average level of water access for livestock diversified only into farming to substitute the effects of water charges on household welfare. Also, the levels of water access for livestock not only push pastoralist households to diversify into farming and off-farm LS but also provide surplus income for meeting other household welfare. The major policy implication of this study is that water access for livestock should be improved by constructing permanent water infrastructures such as boreholes, earth dams and charcoal dams since it enhances livestock production and provides a broadened choice of livelihood strategies that improve household welfare. Therefore, the study recommends that the challenges related to water access for livestock should be addressed by the Government of Tanzania in collaboration with other livestock development partners such as pastoralists, Non-Governmental Organizations and donors. This will ensure the development of the livestock production system and offer a broader choice of LS among pastoralists.

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