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Perceived Effect of Water Scarcity on Livelihood Status of Livestock Farmers in Zamfara State, Nigeria

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Abstract
The study evaluated the impact of water scarcity on the livelihood activities of livestock farmers in Zamfara State, Nigeria. The study adopted a multistage sampling technique to elicit primary data from 360 respondents. Data obtained were analysed using frequency, percentages and structural equation modelling (SEM). Findings revealed that livelihood activities had a direct effect on social networks (β= 0.944, p > 0.01), awareness (β = 0.572, p = >0.01), farmers' perception of water scarcity (β = 0.266, p = >0.01) which were positive and significant. The result shows that R^2 for a social network, awareness and perception were 51.4%, 37.2% and 61% respectively. This means that livelihood activity causes variance in these variables. The study concludes that livelihood activities significantly influence farmers' perceptions of water scarcity. Therefore, government organizations should invest in the development of subterranean water resources to improve water availability. Additionally, farmers should consider investing in rainwater harvesting infrastructure to mitigate the challenges of water scarcity.

Keywords: Water scarcity, livelihood activities, livestock farmers.

Introduction
The global demand for freshwater, particularly for agriculture and livestock production, cannot be overstated. Water availability is increasingly constrained due to natural processes and human-induced activities, including economic and anthropogenic actions (Mathew et al., 2023). These factors lead to a reduction in the amount of water available for food production.

Globally, agriculture consumes about 70% of freshwater resources (Rossana et al., 2023). Water scarcity is a critical issue in the agricultural sector because, without sufficient water, sustainable production is impossible. Even in regions with relatively abundant water resources, the steady demand and daily usage often result in shortages. Both rain-fed and irrigated agricultural water supplies are under significant pressure due to the rising need for food production to support the growing global population (Hemathilake and Champathi, 2021).

In Africa and Asia, 85–90% of freshwater used for agriculture comes from seasonal rivers and rainfall, which creates substantial limitations for agricultural productivity. Urbanization, poor resource management, undetected water leakage, and climate change exacerbate these challenges, particularly in sub-Saharan Africa, where water shortages hinder food production necessary to meet the needs of the population (Cosgrove and Loucks, 2021). Managing water shortages is particularly difficult in rain-fed agricultural communities (Mathew et al., 2023).

Water scarcity is a persistent challenge in the livestock sector across sub-Saharan Africa (Never Assan, 2022). Despite government efforts to address this issue, advancements in farming technology have heightened awareness of the impact of water scarcity on both livestock and crop farmers (Never Assan, 2022). The consequences of water scarcity include regional instability and conflicts, with over 90% of rural and 60% of urban areas affected (Carlo et al., 2023). Competing demands for water make access increasingly difficult for rural populations, undermining food security and livelihoods. Practices such as nomadic and transhumant pastoralism are often driven by water scarcity (Narayan and Nathibai, 2024). Natural phenomena, such as reduced rainfall and declining soil moisture, coupled with human activities, significantly affect water availability. Moreover, water scarcity is not solely an ecological issue but also deeply intertwined with social and political dynamics.

Globally, 66% of farmers experience water scarcity at some point each year, while 844 million people lack access to basic drinking water, and 263 million spend over 30 minutes daily collecting water (FAO, 2018). Over half of those affected live in sub-Saharan Africa, where domestic water sources are often shared with animals (FAO, 2018). Agricultural systems are adapting to water scarcity through shifts in dietary preferences, such as adopting water-efficient crops and livestock, local and seasonal foods, plant-based diets, and sustainable agricultural practices. These changes, driven by increased consumer awareness and innovations like water-saving technologies and alternative proteins, promote sustainable food production while reducing environmental impact.

Livestock farmers' livelihood activities—including economic dependence, direct water usage, environmental factors, and social contexts—shape their perceptions of water scarcity. These perceptions influence their water resource management strategies and their ability to adapt to changing water availability.

In northern Nigeria, low annual rainfall exacerbates water scarcity, dictating survival strategies (Udmale, 2019). Globally, water scarcity results in the loss of lives and the degradation of natural habitats. In Nigeria, desertification has displaced farmers and pastoralists, forcing thousands to abandon their lands. Drought leads to losses in livestock populations, human lives, socio-economic development, and environmental stability, severely limiting agricultural productivity (Godde et al., 2021). Zamfara State faces acute challenges with natural resources, including water and pasture, due to population growth. Increased demand for livestock production and human consumption has directly affected water availability. Water scarcity and insecurity in the state adversely impact livestock production, food security, and livelihoods (Kelechi and Vincent, 2021).

There is a pressing need for empirical research to understand and address these challenges. The study specifically sought to:

(i) examine the relationship between livelihood activities engaged by livestock farmers
(ii) assess livestock farmers' perception of water scarcity.

Methodology

The study was conducted in Zamfara State, located in northwestern Nigeria. Geographically, it is situated at approximately 12.1227° N latitude and 6.2236° E longitude. The state faces significant challenges with natural resources, such as water and pasture, due to population growth. This growth increases demand for livestock production and human consumption, which directly affects water availability. The study area experiences two distinct seasons: dry and rainy. The annual temperature ranges from 25–42°C, and the state receives between 550–900 mm of rainfall annually. The harmattan season occurs between November and February. The state's land is primarily used for crop cultivation, supporting the livelihoods of over 80% of its population. Additionally, Zamfara boasts a substantial livestock population, with over 9 million heads. The study population comprised all registered livestock farmers in Zamfara State.

A multi-stage sampling procedure was employed in selecting 360 respondents for the study. In the first stage, six local government areas (LGAs) were purposively selected from the three (3) administrative zones of the Agricultural Development Project (ADP) in Zamfara State, based on the high intensity of livestock farming. The selected LGAs were Maru, Tsafe, Zurmi, Kaura Namoda, Talata Mafara, and Anka.
In the second stage, three communities were purposively from each LGA due to their prominence in livestock production. In stage three, twenty respondents were randomly selected across the 18 selected communities, making a total sample size of 360 respondents.

Structural Equation Modelling

Structural equation modelling (SEM) was used to examine the relationship between livelihood activities engaged by livestock farmers and their perception of the water scarcity effect in the study area. There are 2 types of SEM analysis, the first one being covariance-based SEM and the second one being variance-based, which is called partial least squares (PLS). PLS-M a partial least square method has been employed for this study because it does not perform assumptions about the distribution of the data; and maximizes the explained variance and minimizes the overall error.

In addition, each PLS Path Model consists of two sub-models, a measurement model and a structural model. The study followed the two-stage model-building process for applying SEM as suggested by Hair (2014). The model specification has one dependent variable, two mediating variables, and one independent variable. The dependent variable is livelihood activities. The mediating variables are awareness and

social network. The independent variable is perception of water scarcity effect. Each of these variables was measured by construct and items.
In the model, there are four latent constructs: livelihood activity, perception, awareness, and social network. Livelihood activity was measured by three indicators: On-farm activity (LHE_1), Off-farm activity (LHE_2) and Non-farm activity (LHE_3).

Four indicators were used to assess perception knowledge of the change in the availability of water ($Percep_1$), Knowledge of the change in the quality of water ($Percep_2$), Knowledge of current water availability status ($Percep_3$), and Expectation of water scarcity in the future ($Percep_4$). Awareness was measured by the following indicators: understanding of the consequences of water scarcity ($Aware_1$), Mindfulness of respondents about the extent of water scarcity ($Aware_2$) and Importance of water saving ($Aware_3$). The three indicators which measure Social Networks include: Interaction with families who had water scarcity experience (Network 1) and contact with other villagers. (Network 3) and contact with a government official or extension agent. (Network 3).

Table 1: Measurement Model Analysis

Assessment test	Name of index	Level of acceptance	Literature support
1. Reliability	1.Internal consistency reliability	Cronbach Alpha > 0.7	Hair et al., (2014)
		Composite reliability > 0.708	
2. Convergent validity	1.Average variance explained (AVE)	AVE score > 0.5	Hair et al., (2014a)
	2. Factor loadings	Loadings for indicators > 0.708	Hair et al., (2014a)

Partial least square structural equation model results evaluation
The evaluation of the PLS-SEM results begins with the evaluation of the measurement model and continues with the evaluation of the structural model. These guidelines provide rules of thumb to explain the adequacy of the results. This involves the assessment of the reliability and validity of the key latent constructs and indicators to complete the study of the structural models. To measure the convergence validity of each construct, factor loadings, Average Variance Extracted (AVE), and Composite Reliability (CR) were used. The recommended cut-off values suggested by Hair et al., (2014a), such as the “standardized factor loading” (>0.7), the “composite reliability, CR” (>0.7), the “average variance extracted, AVE” (>0.5), were employed. The results show that the value of AVE of all constructs was greater than 0.50, which provides the basis for the convergent validity of the measurement (Hair et al., 2014). The composite reliability (CR) for all constructs also was above the acceptable value of 0.70. Meanwhile, the result of Cronbach’s alpha coefficient suggested that Cronbach’s alpha of all the research variables had an acceptable reliability as they were greater than 0.70.

Assessment of the smart PLs SEM outer model

The measurement or outer model shows the model's validity and reliability (as presented in Table 2). The Table shows the results of Cronbach's alpha (α), C. R., and the AVE scores for all the latent dimensions surpassed the proposed cut-off level and indicated that the scale items have proper internal reliability and convergent validity. Cronbach alpha for Perception (α = 0.872, C.R = 0.914, AVE = 0.740); Awareness (α = 0.854, C.R. = 0.876, Ave = 0.723); Network (α= 0.779, C.R. = 0.832, Ave = 0.667); and Livelihood (α= 0.823, C.R. = 0.912, Ave = 0.737). The results showed that the value of AVE of all constructs was greater than 0.50, and CR for all constructs was also above the acceptable value of 0.70. Meanwhile, the results suggested that Cronbach's alpha of all the variables had an acceptable reliability value of more than 0.70. Therefore, all the values meet the criteria for reliability of the Model.

Table 2. Assessment of the smart PLs SEM outer model

	Cronbach's alpha	Composite reliabilityrho_a	Composite reliability rho_c	Average variance extracted(AVE)
Perception	0.872	0.914	0.947	0.740
Awareness	0.854	0.876	0.922	0.723
Network	0.779	0.832	0.882	0.667
Livelihood strategy	0.823	0.912	0.919	0.737

Source: Author's Computation, 2023

Evaluation of the smart PLS- SEM structural model

The second aspect of PLS-SEM is the estimation of the structural model. This was assessed by evaluating the R^2 and path coefficient (β) values. Several metrics were examined to check the model's goodness of fit (GoF). To secure a proper model fit, the minimum acceptable R^2 score was 0.10 (Hair *et al*., 2014). The R^2 values of all the exogenous latent variables were 0.514, 0.610 and 0.372, respectively. This implies that the study model has adequate predictive power and also indicates that all the constructs significantly affect the endogenous latent variable. For the path coefficients, β values of each path were found to be 0.944 for livelihood activity, 0.386 for the social network, 0.464 for perception, and 0.572 for awareness respectively.

Results and Discussion

Table 3 shows the results of path analysis. The findings revealed the direct effect of livelihood activity engaged by livestock farmers on social networks, (β = 0.944, p > 0.01), awareness (β = 0.572, p = >0.01), and farmers' perception of water scarcity (β = 0.266, p = >0.01), were positive and significant respectively. Thus, the null hypotheses H_{O1}, H_{O2}, and H_{O3} were rejected. Therefore, it can be concluded that; livelihood activity had a significant effect on farmers' perception of water scarcity, social networks and farmers' awareness.

Mediation analysis was also performed to assess the mediating role of social networks and awareness of the linkage between livelihood activity and perception of water scarcity. When the mediators i.e. social network and awareness were included between livelihood activity and perception of water scarcity the results show a positive and significant relationship of livelihood activity on perception of water scarcity through social network (β=0.386, p<0.01) and through awareness with (β=0.464, p<0.01).

Here, the direct effect of livelihood activity on perception of water scarcity was less than the indirect effect when social networks and awareness were included between livelihood activity and perception of water scarcity.
The study found that the Variance Inflation Factor (VAF) value was 45% for the mediation effect of the social network in the relationship between livelihood activity and perception of water scarcity, and the VAF was 55% for the mediation effect of awareness in the relationship between livelihood activity and perception of water scarcity. Therefore, partial mediation exists between livelihood activity and the perception of water scarcity. Hence, it leads to reject the null hypothesesH_{O4} and H_{O5}.
The result shows the R^2 for social network and awareness were 0.514, and 0.372, respectively, which means livelihood activity causes variance in social network and awareness to 51.4% and 37.2% that is a strong explanation by the variable whereas the R^2 value of perception was 0.610 that means livelihood activity causes variance in perception of water scarcity through social network and awareness to a61% that is also strong explanation. Therefore,
This study shows that livelihood activities significantly influence livestock farmers' perceptions of water scarcity, primarily through social networks and awareness. Adequate water is essential for the socio-economic well-being of livestock farmers.

Table 3: Result of path analysis

	Coefficient β
Direct effect	
Livelihood activity -> Perception	0.266*
Livelihood activity -> social network	0.944*
Livelihood activity -> Awareness	0.572*
indirect effects	
Livelihood activity -> social network -> perception	0.386*
Livelihood activity -> awareness -> perception	0.472*
Total Effect	
Livelihood activity -> Perception	0.858*
R-square	
Perception	0.610
Network	0.514
Awareness	0.372

Source: Author’s Computation, 2023

Conclusion and Recommendations

This study underscores the critical role livelihood activities play in shaping livestock farmers' perceptions of water scarcity, with social networks and awareness emerging as key influencing factors. Ensuring an adequate water supply is vital for the socio-economic stability and well-being of livestock farmers, emphasizing the need for sustainable water management practices and policies to support this community. Among the various livelihood strategies, livestock and crop production remain the most widely pursued by households in this sector.

To address these challenges, there is a need to develop and maintain water management systems, such as reservoirs, wells, and irrigation networks, to provide a reliable water supply for livestock farmers. Encouraging the adoption of water-efficient technologies through subsidies, training programs, and awareness campaigns is equally important. Facilitating the formation of cooperatives and networks can enhance the sharing of information on water management practices and strategies to mitigate water scarcity. Educational initiatives should raise awareness about water conservation and the adoption of sustainable practices in livestock farming.

In addition, policies regulating water extraction must be developed and enforced to prevent overuse and ensure equitable distribution among stakeholders. Research into drought-resistant feed crops and water-efficient livestock management techniques should be prioritized to help farmers adapt to water scarcity. Providing financial incentives and support for sustainable water management practices and technologies is essential. Finally, robust systems must be established to track water consumption and evaluate the effectiveness of implemented strategies, enabling data-driven adjustments to policies and practices.

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