



Socio-Economic Analysis of Smallholder Water User's Participation on Water Resources Management in Tanzania: A Double Hurdle Analysis

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Abstract

Background: Community participation in water resources management is one of the important areas that need emphasis on the implementation of National Water Policy. Despite various initiatives, the situation is still alarming. **Objective:** This study is intended to assess the factors affecting smallholder water user's participation and the extent of participation in water resources management in Tanzania. **Methodology:** A quantitative, cross-sectional study was employed to assess all the selected 397 smallholder water users in Mvomero district (particularly Mlali & Dakawa wards). The study employed the probability sampling through the use of questionnaires to collect data. However, the study used both descriptive and econometric analysis. The researcher employed a double hurdle model to analyze the factors affecting smallholder water user's participation and the extent of participation in water resources management. **Results:** The results of the study indicated that the participation in water resources management was influenced by age, marital status, primary occupation, involvement in more than one activity, household size, awareness, water resources management actors and land size, while the extent was influenced by education level, primary occupation, household size, awareness and decision making. **Conclusions:** The study suggested that the government should emphasize the water resources management by supporting mass education, information provision, proper land distribution system. Additionally, more emphasis should be placed on managing the resources wisely to alleviate poverty.

Subject Areas

Environmental Sciences

Keywords

Participation, Water Resource Management, Smallholder Water Users, Double Hurdle Model, Econometric Analysis

1. Introduction

Water is a fundamental resource for human existence, and its availability and quality are critical for societal well-being. The sustainable management of freshwater resources underpins social development and economic prosperity across the globe [1]. A significant portion of the global workforce operates in sectors heavily dependent on water such as agriculture, mining, and various industrial processes including those in the paper and pharmaceutical industries. With the intensification of climate change, the availability of surface water is projected to decline, thereby increasing the vulnerability of water-dependent livelihoods [2].

Approximately 1.2 billion jobs in sectors like construction, transportation, and recreation are considered moderately water-dependent, as they require water but in less intensive volumes [3]. Overall, an estimated 78% of global employment is tied to water availability in some form. Yet, as water scarcity becomes more prevalent due to droughts, floods, and climatic variability, the ability of water resources to support growing populations and intensified industrial production is under threat [4].

This intensifying pressure on water resources is further complicated by weak institutional support and governance issues in many regions, particularly among smallholder communities whose livelihoods rely on effective irrigation and water conservation strategies [3]. As a result, the increasing gap between water demand and supply could severely impact global employment trends, especially in agriculture and other labor-intensive sectors [1]. Addressing this challenge necessitates robust investments in adaptive water management practices and local-level governance improvements that ensure equitable and sustainable access to water [3] [4].

Globally, the demand for water resources has risen sharply in recent years due to accelerated economic development and rapid population growth. As global populations expand, the pressure to increase food production intensifies, thereby escalating the need for water in agricultural activities [1]. This is particularly critical in regions with arid and semi-arid climates, where water scarcity poses a major challenge to sustainable farming [2]. The situation is further exacerbated by the impacts of climate change, which disrupt water availability and increase the frequency of extreme weather events such as droughts and floods, further threatening food security and water sustainability [3].

Moreover, smallholder farmers, who are essential to food systems in many developing countries, face significant constraints in accessing reliable water sources for irrigation. Addressing these challenges requires not only technological solutions

like on-farm water storage systems but also stronger institutional frameworks and governance mechanisms that support water access and efficient use [4]. For example, the estimates provided by one of the published World Water Development Report pointed out that nearly two-thirds of the world's population faces water scarcity for at least a month in a year, and this is approximately expected to increase by 2040 whereby 1 of 4 people around the world will be living in areas with severe water scarcity. But on the other side, the UN water report shows that industrial expansion and increased domestic uses for water have increased demand for water between 20% and 30% [5].

In Africa, the water crisis is becoming increasingly severe, largely driven by the continent's rapid population growth. Africa remains the fastest-growing region globally, with its population expected to nearly double by 2050, a trend that poses significant challenges for sustainable water resource management [3]. As population pressure mounts, the demand for freshwater, particularly for agricultural and domestic use, continues to escalate, intensifying existing water scarcity issues across the continent [3].

Current projections indicate that by 2030, between 75 million and 250 million people in Africa could be living in areas under high water stress, with rural farming communities being the most vulnerable [1]. Many African countries face compounding challenges including weak governance, limited infrastructure, and insufficient institutional support, all of which hinder the effective management of water resources [4].

In Tanzania and across many African countries, ensuring the sustainable management and availability of water resources has become a central concern in national and regional policy agendas. This shift stems from global initiatives such as the 1992 World Summit on Sustainable Development, which introduced Agenda 21 and emphasized integrated and participatory approaches to freshwater management. As a result, the concept of community participation became widely adopted, prompting many African nations to reform their water policies to incorporate local engagement and governance frameworks. These reforms aimed to strengthen institutional capacity, improve accountability, and promote long-term sustainability. In Kenya, for example, efforts to modernize irrigation systems have aligned with this participatory model, yet significant challenges persist, including poor infrastructure, fragmented institutional coordination, and inadequate funding.

Since gaining independence in 1961, Tanzania's approach to water resource management was initially centralized, with the government acting as the sole planner, investor, and executor of water-related projects. This centralized strategy was formalized in the National Water Policy of 1991, which positioned the central government as the key authority in protecting and managing water resources. However, influenced by global shifts in governance promoted by the 1992 Earth Summit and Agenda 21, Tanzania revised its policy in 2002 to adopt a more decentralized and participatory approach. The updated policy emphasized the active

involvement of communities in all stages of water resource management, including planning, construction, operation, maintenance, and monitoring. The role of the central government transitioned from direct service provision to a more strategic role focused on policy formulation, regulation, and coordination. This shift aligns with broader continental trends observed in other African contexts, where inclusive and bottom-up water governance is gaining traction. For instance, in Kenya, participatory models have been promoted to improve smallholder access to water through on-farm storage solutions [4], while in Zimbabwe, adaptive capacity in irrigation is increasingly shaped by socio-demographic and governance factors at the community level [3]. Similarly, in India's semi-arid Purulia district, sustainable water resource management has been guided by decentralized governance and local participation, especially in alignment with the Sustainable Development Goals [2]. These examples underscore a continental and global movement toward empowering local actors in water governance to enhance resilience and sustainability.

The implementation of Tanzania's National Water Policy engages a broad spectrum of stakeholders, notably including smallholder farmers who play a central role in its execution. These smallholders actively participate in water resource management, particularly through irrigation practices, which continue to offer significant potential for enhancing agricultural productivity and ensuring food security. Irrigation systems not only provide affordable and direct benefits to farmers but also contribute to broader rural development. Moreover, the policy fosters inclusive governance by enabling smallholder participation in Integrated Water Resources Management (IWRM), promoting sustainable and equitable water use for both individual and national development [6] [7].

Although Tanzania revised its National Water Policy in 2002 to address shortcomings of the 1991 version, effective water resource management remains a significant challenge. According to the United Nations World Water Development Report [8], the per capita renewable freshwater resources have declined sharply over the past three decades from 3000 m³ to approximately 1600 m³ primarily due to increasing water demand, particularly in the agricultural sector. Agriculture continues to account for about 89% of total water withdrawals in Tanzania, significantly exceeding the global average of 70%. Projections suggest that by 2025, per capita freshwater availability could fall below 1400 m³, placing further stress on already vulnerable water systems. In light of these pressures, the report urges improved coordination across sectors, the adoption of sustainable water pricing mechanisms, greater investment in water infrastructure, and enhanced data collection and analysis to support informed policy-making and long-term water security [8] [9].

In Tanzania, the majority of the poor reside in rural areas where smallholder agriculture is the primary source of livelihood. Many smallholder farmers living near river basins rely on irrigation to support year-round agricultural activities. Because water is accessed and utilized at the lowest levels of the basin, the active

participation of smallholder water users in the governance and management of water resources is critical for achieving sustainability. Given the central role of water in sustaining rural livelihoods, it is essential not only to ensure that smallholder farmers especially those from disadvantaged communities are involved in water management, but also that they derive tangible benefits from their participation. This involvement should be structured to enhance access, create opportunities, and promote inclusive development [7] [10].

Building on this context, the objective of this paper is to examine the factors influencing the participation of smallholder water users and to assess the level of their engagement in water resource management, with a specific focus on smallholder communities in Mvomero District, Tanzania.

2. Data Source, Methods and Model Setting

2.1. Data

To analyze the factors affecting smallholder water user's participation and the extent of participation in water resources management in Mvomero district. The study adopted primary data with a probability sampling to select the respondents to be in the sample. Simple random sampling was used to select households to be included in the survey. The Structured questionnaires were used to obtain reliable information from the 397 respondents. However, the data were collected following all ethical matters such as confidentiality and informed consent. Moreover, the data were managed using SPSS version 23 and later on were subjected to analysis using STATA version 17 where a Double Hudle Regression Model were run.

2.2. Methods

The study employed quantitative approach as a major design whereby a cross-sectional survey was conducted to households resided at Mvomero district in Tanzania (see **Figure 1**). The district was chosen because of the presence of livelihood activities that depend on the use of water resources, particularly surface water from rivers. Also, the area receives rainfall about 267.03 millimeters (10.51 inches) annually making the water sources with a supply of enough water for irrigation practices. However, the area has both irrigation practices *i.e.* traditional and modern irrigation schemes, for the case of modern irrigation schemes include the likes of Dakawa irrigation schemes, Uwawakuda scheme, Stima scheme, Chiteni and Upata irrigation schemes in both Dakawa and Mlali wards. While, majority of the people use traditional irrigation methods. Lastly, the main economic activities that are carried out in the district include Agriculture, livestock keeping and Trade.

Therefore, the study was conducted in two wards namely Mlali and Dakawa. The reason for choosing the two wards is to enable a comparison of two locations. The two wards differ in the sources of water that people use to conduct their livelihood activities. While Mlali village depends on water from the river and gravity water from Mongwe, Dakawa uses the Wami river as the main water source. In addition, most of the water committees or water user's associations in Dakawa are

registered (formal) by the government compared to Mlali where there are still informal committees and associations for water management.

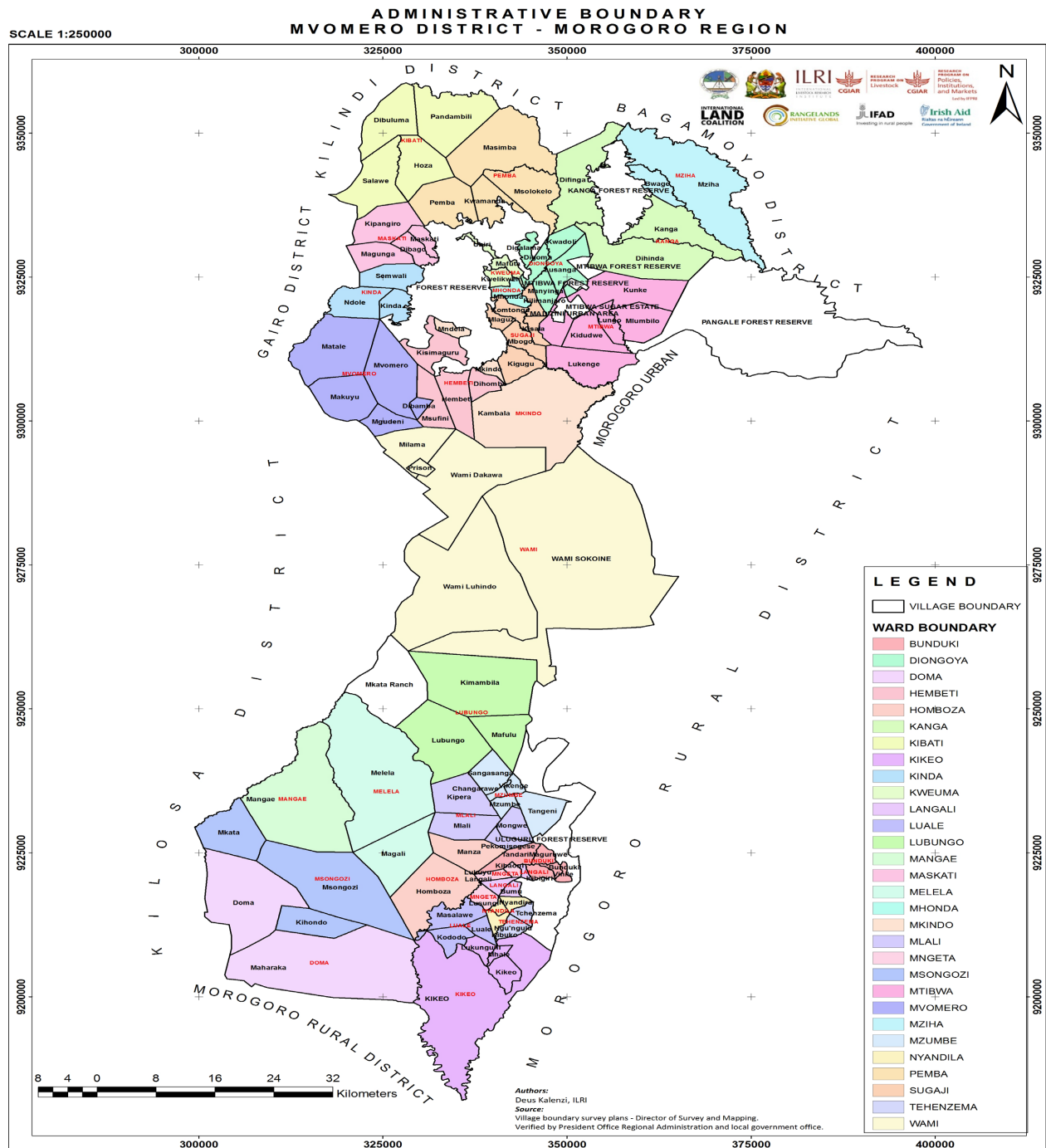


Figure 1. A map of Mvomero District showing Mlali & Dakawa wards. (Source: Google Maps)

Since the interest is in the representativeness of concepts in their varying form. Thereafter, simple random sampling performed to select households to be included in the survey, while the sampling frame consisted of the people who participate and who don't participate in water resources management. The households

identified from the village office records or the water committee or associations chairpersons.

The sample for the study was drawn from Mlali and Dakawa wards and it included all the respondents participating and not participating in water resources management with ages starting from 18 years and above.

Thus, in the preparation of the sample regarding the related study the researcher calculates the sample using Yamane (1967), the formula for calculating sample size from the population targeted.

$$n = \frac{N}{1 + N(e)^2}$$

Details:

n = this represents the sample size selected.

N = this represents the targeted population in which the researcher has identified as **59,400** from Dakawa and Mlali wards (See **Table 1**).

e = this involves the sampling error percentage which the researcher has chosen as 5%.

$$n = \frac{59400}{1 + 148.5}$$

$$n = \frac{59400}{149.5}$$

$$n = 397.3244 \approx 397$$

Then 397 sample size was used.

Out of 397 respondents, data collected from 182 respondents in Mlali ward, and the rest 215 were selected from Dakawa ward.

Table 1. Household's population from the two wards.

Name of the ward	Household population
Mlali ward	23,320
Dakawa ward	36,080
Total	59,400

Source: (Mlali census 2012 and Dakawa Ward Council, 2020).

2.3. Model Setting

A Double Hurdle Model

Mostly water resources are governed by policy and regulations to maintain its sustainability, this means that smallholder water users might participate or not participate in water resources management. But also, participation in water resources management can be affected by factors that smallholders have access to the management. This makes participation a two-stage process, thus estimating the parameters of participation in water resources management that could provide

a biased estimate if we assume that factors affecting participation in water resources management are independent of participation in water resources management. In this case, a Double hurdle model was employed.

This study employed the Double Hurdle model to examine both the decision to participate and the extent of participation of smallholder water users in irrigation-based water resource management. The Double Hurdle model was selected for its flexibility in handling situations where two distinct processes influence an outcome: the initial decision to participate and the subsequent level of involvement. Unlike the Heckman selection model, the Double Hurdle model allows for different explanatory variables to influence each decision stage independently or simultaneously, depending on the research context. In this study, it was assumed that smallholder water users face two sequential decisions. The first hurdle captures the probability of participation in water resource management, while the second hurdle assesses the extent of their involvement, measured by the number of meetings conducted annually by Water User Associations (WUAs) or water committees. The outcome equation for the second hurdle used a truncated regression model, focusing on active participants only. Although the model permits separate determinants for each stage, this study assumes a common set of explanatory variables influencing both participation and its intensity [11] [12].

The Double-hurdle model was explained as follows:

The first hurdle (smallholder water user's participation)

The probability that smallholder water users to participate in water resources management is assumed to be determined by an underlying response variable that explains the water user's demographic, institutional and socio-economic characteristics, thus can be illustrated as:

$$D_i^* = x_i' \beta + \varepsilon_i \quad (1)$$

where D_i^* is a latent variable that shows whether individual participate or not participate in water resources management, β denotes the vector of unobserved served parameters to be estimated, x_i' denote the vector of observed independent covariates explaining the event, lastly ε_i denotes unobserved error term capturing other factors and is assumed to be independent and normally distributed. That is $\mu_i \sim N(0, 1)$, and $D_i = 1$ if $D_i^* > 0$

$$D_i = 1 \text{ if } D_i^* \leq 0$$

The variable D_i present the value of 1 if the smallholder water users participate and the marginal utility over participating is greater than not participating and zero (0) otherwise. The binary variable of smallholder water user's participation D_i is assumed to be a probit model and is specified as:

$$\Pr(D_i = 1/x_i) = \phi(x\beta) + \varepsilon_i \quad (2)$$

where Pr presents the probability of smallholder water users to participate: D_i is the binary variable of smallholder water user's participation: ϕ denotes the cumulative normal distribution: x is the vector of a smallholder water users demographic, socio-economic and institutional characteristics denote the coefficient to

be estimated and ε_i denote the random error term distributed normally with zero mean and constant variance [13].

The second hurdle (the extent to which smallholder water users participate)

The extent to which the smallholder water users participate D^* is assumed to be truncated normal distribution with parameters to be different from the Probit model that can be estimated as follows:

$$D^* = x_i' \alpha + \mu_i \quad (3)$$

where D^* is the observed extent of participation measured by the actual number of meetings conducted by water associations or committees, x_i indicate the vector of covariates that explain the extent, α is a vector of unobserved parameters to be estimated and ε_i is a random variable that denotes all other factors apart from X. Since the assumption of independence of the two error terms, later on, it was suggested that the hurdles can be estimated by the maximum likelihood method of Probit and truncated regressions. The analysis of the model was performed by STATA software version 15.0 by considering the assumption that the two error terms are normally distributed and uncorrelated. Then using the same software Multicollinearity and Heteroscedasticity were taken into consideration, where vce (robust) command was introduced after the Craggit command.

The data for variables affecting the participation in water resources management and the extent of the participation was collected from 397 respondents in two wards of Dakawa and Mlali in Mvomero district (See **Table 2**).

Table 2. The variables description & measurement.

Variables (Dependent)	Measurements	Categories	Expected outcome
Smallholders water users participation in WRM	1 if smallholder water users participate in irrigated water management 0 otherwise	Binary	
Level of participation	How many times people have participated in water committees or associations meetings.	Continuous	
Independent variables			
Age	The number of years that a household head has lived/number of age per smallholder water user	Continuous	Positive
Age-squared	The squared number of years that a household head has lived (However natural logarithms were used in the analysis)	Continuous	Positive
Household sex	1 for male 0 female	Binary	Positive
Marital status	The status that if smallholder is married or not married 1 for Married 0 for Unmarried	Binary	Positive

Continued

	1 for none 0 for otherwise		
Educational level	1 for primary education 0 for otherwise 1 for secondary education 0 for otherwise 1 for college/university education 0 for otherwise	Binary	Positive
	1 for self-employed 0 for otherwise		
Households Primary Occupation	1 for employed 0 for otherwise 1 for a farmer 0 for otherwise 1 for fishers 0 for otherwise 1 for others 0 for otherwise	Binary	Positive
Household size	The number of households in the family	Continuous	Positive
Information dissemination	1 If smallholder water users are being informed concerning the water resources management 0 otherwise	Binary	Positive
Involvement in Decision making	1 if smallholder water users are involved in decision making 0 otherwise	Binary	Positive
Awareness	1 if the smallholder water users are aware of water resources management 0 otherwise	Binary	Positive
Water resources management actors	1 for state actors 0 for non-state actors	Binary	Positive
Involvement in more than one activities	The activities that smallholder water users indulge in or not 1 if yes 0 if no	Binary	Positive
Income	The amount of money that households get monthly/Continuous variable measured in terms of amount spent	Continuous	Positive
Land ownership	1 if smallholder water users own a land 0 otherwise	Binary	Positive
Land size	The size of land owned by smallholders in terms of hectares	Continuous	Positive

Source: Authors Construction (2025).

3. Results and Discussions

Descriptive statistics of the socio-demographic characteristics of the smallholder water user's was analyzed through tables, frequency distribution, percentages,

mean, standard deviation, minimum and maximum values. The findings in **Table 3** shown that, 217 out of 397 respondents participated in water resources management, and was characterized in a way such that; majority of the respondents in both Dakawa and Mlali wards were males making about 70.78% and the rest 29.22% were females, the age of the respondents was averaged at 34 years with minimum age of 18 years and maximum age of 49 years. However, the marital status showed that majority of the respondents in both wards were married marked with 72.29% compared to unmarried respondents with the remaining 27.71% suggesting that married respondents engage in various development activities compared to unmarried ones.

Table 3. Descriptive statistics for socio-demographic characteristics.

Variables	Categories	Frequency	Percent (%)
Participation	Participated	217	54.66
	Not-participated	180	45.34
Respondents sex	Male	281	70.78
	Female	116	29.22
Marital status	Married	287	72.29
	Unmarried	110	27.71
Education level	No formal education	66	16.62
	Primary education	92	23.17
	Secondary education	176	44.33
	College/University education	63	15.87
Primary occupation	Self-employed	112	28.21
	Employed	129	32.49
	Farmer	149	37.53
	Fishers	5	1.26
	Others	2	0.50

Source: Field Data (2020).

However, their education status indicated that most of the respondents attended a school with the distribution of 44.33% (secondary education), followed by 23.17 attended only primary education, but also respondents with college or university education averaged at 15.87% and lastly respondents with no formal education presented with only 16.62%. For the case of primary occupation engaged by the respondents, the findings revealed that most of them engaged in various occupation as their primary occupation including farming (37.53%), fishing (1.76%), employed (32.49%), self-employed (28.21) and other occupations averaged with only 0.5%.

Furthermore, most of the families had average of three (3) people and lastly the income of the respondents was averaged at 293173.8 with minimum income of 37,000 and a maximum income of 650,000 per month in Tanzanian Shillings. (See **Table 4**).

Table 4. Descriptive statistics for continuous variables.

Variable	Observation	Mean	Std. Dev.	Min	Max
Household Size	397	3.062972	1.847347	1	11
Income	397	293173.8	139721.3	37,000	650,000
Age	397	34.03275	8.645162	18	49

Source: Field Data (2020).

Table 5. Double hurdle model regression results for factors influencing participation and the extent of participation in water resources management.

VARIABLES	PARTICIPATION				EXTENT OF PARTICIPATION				
	Tier1 (Probit regression)				Tier2 (Tobit regression)				
	Coefficients	Std. Err.	Z	P > z	Coefficients	Std. Err.	Z	P > z	dy/dx
Age	-0.195783	0.102289	-1.91	0.056**	-0.04254	0.073054	-0.58	0.56	-0.1957831
Ln_Age2	3.079528	1.592592	1.93	0.053**	0.993665	1.151437	0.86	0.388	3.079528
Sex_01	0.2658951	0.380888	0.7	0.485	-0.19392	0.212345	-0.91	0.361	0.2658951
Mstatus_01	0.7039428	0.287139	2.45	0.014**	0.067832	0.161727	0.42	0.675	0.7039428
Edu_01	0.3325	0.331919	1	0.316	0.347551	0.289734	1.2	0.23	0.3325
Edu_02	0.0189711	0.44075	0.04	0.966	0.3983903	0.248793	1.6	0.109	0.0189711
Edu_03	-0.166998	0.519515	-0.32	0.748	1.24085	0.444527	2.79	0.005***	-0.1669979
PrOccup_01	-0.064392	0.395055	-0.16	0.871	-0.23188	0.209682	-1.11	0.269	-0.0643918
PrOccup_02	-0.428665	0.316971	-1.35	0.176	-0.10415	0.170545	-0.61	0.541	-0.4286653
PrOccup_03	2.730331	0.679027	4.02	0.000***	-0.79399	0.418649	-1.9	0.058**	2.8730331
PrOccup_04	2.700124	0.673841	4.01	0.000***	-1.28605	0.822005	-1.56	0.118	2.700124
Invomore_01	0.613627	0.311989	1.97	0.049**	-0.19228	0.137073	-1.4	0.161	0.613627
Ln_income	-0.704754	0.503308	-1.4	0.161	-0.55338	0.342368	-1.62	0.106	-0.704754
Household size	-0.261597	0.094306	-2.77	0.006**	0.203506	0.094548	2.15	0.031**	-0.2615974
Information_01	-0.409714	0.467119	-0.88	0.38	0.075474	0.240313	0.31	0.753	-0.4097141
Awareness_01	-0.541899	0.277624	-1.95	0.051**	-0.48033	0.172849	-2.78	0.005***	-0.5418985
Wrmactors_01	0.4908529	0.250194	1.96	0.050**	-0.17579	0.154356	-1.14	0.255	0.4908529
Decisionmaking_01	-0.221289	0.281979	-0.78	0.433	0.268908	0.15601	1.72	0.085*	-0.2212888
Landownership_01	0.2738181	0.322336	0.85	0.396	-0.06827	0.357803	-0.19	0.849	0.2738181
Land size	0.3484104	0.153723	2.27	0.023**	0.003742	0.152841	0.02	0.98	0.3484104
_cons	-4.539071	9.619859	-0.47	0.637	2.958581	6.991548	0.42	0.672	0.000
Sigma									
_Constant	1.28732	0.169918	7.54	0.000	1.28732	0.169918	7.54	0.0000	
Regression Diagnostics (Probit)		Values		Regression Diagnostics (Tobit)			Values		
Number of Observation		397		Number of Obs			397		
Log-likelihood		-189.13067		F(19,378)			2.22		
Wald chi2 (18)		3484.31		Var of y*			1.561635		
Prob > chi2		0.000		Var of Error			0.2711814		
Pseudo R2		0.3053		AIC			1364.043		
Correctly classified		76.71%		BIC			1535.352		

Empirical Results

Table 5 presents a double hurdle model regression result for factors affecting smallholder water user's participation and the extent of participation on water resources management in Tanzania.

The results Diagnostics shown in **Table 5**, considering Akaike's information criterion and Bayesian information criterion, it was indicated that the AIC was less than BIC, suggesting that, in a double hurdle model, the probit model fitted than Tobit model.

Remember, the model analyzed the factors affecting smallholder water user's participation in water resources management (taken as participating in irrigation water management) and the number of meetings as the extent of participation in water resources management. The results on the first tier (probit model) indicate that age, age-squared, the dummy of marital status, dummy of primary occupation, involvement in more than one activity, household size, awareness, water resources management actors (state actors) and land size. While in the second tier the dummy of education level, primary occupation, household size, awareness and decision making. The discussions on factors were:

The study findings revealed that household age (both age and age-squared) was statistically significant in the first hurdle of the double hurdle regression model, indicating that age influenced the decision to participate in water resource management. However, the influence was negative, suggesting that younger individuals were less likely to engage in water governance. The non-linear relationship implies that while participation initially decreases with age, it begins to increase as individuals grow older. This may be due to the fact that older household members often have more time, experience, and perceived responsibility, making them more inclined to participate in community water management activities. These results are consistent with recent studies such as by [14], who found that older farmers were more engaged in irrigation governance in central Tanzania due to their stronger social ties and traditional knowledge. Similarly, [15] observed a U-shaped age effect in Uganda, where both the youngest and oldest cohorts showed greater involvement compared to middle-aged groups. However, in the second hurdle of the model, household age did not significantly influence the extent of participation, suggesting that while age affects the decision to join, it does not necessarily affect the level of involvement once engaged.

The findings of the study revealed that marital status positively influenced the decision to participate in water resource management. Specifically, married smallholder water users were more likely to engage in management activities compared to their unmarried counterparts. This suggests that married individuals may feel a greater sense of responsibility toward securing water access for household needs, or may view participation as a means to contribute to household welfare and income. These results are consistent with recent findings by [16], who observed that marital status significantly influenced participation in community water initiatives in Morogoro Region, Tanzania. Similarly, [17] found that married individuals

in rural Uganda were more committed to community development projects, including water governance, due to shared household obligations. However, in the second hurdle of the model, marital status did not significantly influence the extent of participation, implying that while being married increases the likelihood of joining, it does not necessarily affect how actively individuals engage once involved.

Education levels were categorized as none, primary, secondary, and college or university education. The results from the double hurdle regression model indicated that having primary or secondary education did not significantly influence the decision to participate in water resource management. Moreover, college or university education was also found to be statistically insignificant in the first hurdle (participation decision). However, in the second hurdle (extent of participation), higher education was positively associated with increased participation and statistically significant at the 1% level ($p = 0.005$). This suggests that individuals with tertiary education were more actively involved in water resource management compared to those with no formal education. A plausible explanation is that higher educational attainment is linked with increased awareness, multitasking ability, and better understanding of resource governance, all of which enhance engagement in community-based management activities.

According to the findings, it was revealed that smallholders whose primary occupation was fishing or categorized as “other” were more likely to decide to participate in water resource management compared to those who were self-employed, formally employed, or even farmers. This could be attributed to the fact that fishers are often subject to direct regulatory frameworks and environmental laws, making them more accustomed to resource governance practices. However, in the second hurdle of the double hurdle model, the results showed that neither fishers nor individuals in other occupations significantly influenced the extent of participation. These results are consistent with recent findings [18], who noted that occupation type shapes initial participation decisions due to livelihood dependence on water bodies, yet it does not necessarily translate to deeper or sustained engagement in governance activities. Similarly, [19] observed that while fishers are often included in policy frameworks, their long-term participation tends to be limited by institutional constraints and weak follow-through mechanisms.

According to the findings, smallholders whose primary occupation was fishing or categorized as “other” were more likely to decide to participate in water resource management compared to those who were self-employed, employed, or even farmers. This is likely because fishers operate under direct environmental and regulatory frameworks, making them more familiar with resource management protocols. However, in the second hurdle of the regression model, the results indicated that neither fishers nor individuals in other occupations significantly influenced the extent of participation. These findings align with recent research by [20] who observed that occupational engagement influenced initial participation

decisions in community water governance but not the depth of involvement. Similarly, a study by [21] in Tanzania found that while fishing communities were structurally included in water resource governance, their sustained participation was limited by weak institutional mechanisms and lack of feedback integration in policy enforcement.

The findings from the double hurdle regression analysis indicated that smallholders engaged in more than one livelihood activity had a higher probability of participating in water resources management compared to those not involved in multiple activities. This outcome suggests that individuals practicing diversified livelihoods such as combining agriculture with small-scale trade or fishing have greater motivation to engage in water governance due to their increased dependency on water resources. These results are consistent with recent studies by [22] who found that livelihood diversification among rural households in Tanzania significantly predicted active involvement in water user associations. Similarly, [23] reported that smallholders managing multiple income-generating activities are more likely to support collective water management efforts due to heightened awareness of water-related risks and benefits.

According to the results presented in the previous chapter, household size significantly influenced both the decision to participate and the extent of participation in water resources management. Specifically, in the first tier of the double hurdle model, an increase in household size was associated with a reduced probability of participation. Conversely, in the second tier, larger household size positively influenced the extent of participation, suggesting that while larger households may face initial constraints to engage, those who do participate tend to be more involved. These findings are in line with recent studies by [24], who observed similar dynamics in the Rufiji Basin, Tanzania, indicating that large households allocate more labor to community water initiatives. Likewise, Tizikara and Komakech (2022) found that in Uganda's smallholder irrigation schemes, household size had a dual effect negatively affecting participation likelihood but positively influencing the intensity of involvement once committed.

Regarding awareness, the double hurdle regression analysis revealed that being aware of water resource management surprisingly decreased the probability of participation compared to not being aware. This could be attributed to the perception among some informed individuals that participation offers limited tangible benefits, or to misinformation and misunderstandings about the actual processes and outcomes of water governance. These findings align with recent observations by [25] who reported that while awareness levels were relatively high among rural communities in northern Tanzania, skepticism and lack of trust in water governance institutions reduced participation rates. Similarly, a study by [26] in Kenya noted that incomplete or distorted awareness led to passive engagement, particularly where communities lacked feedback mechanisms or observed little change from previous involvement.

However, these findings contrast with those of [27] who found that awareness

significantly increased participation in community-based water and sanitation projects in central Tanzania. In the same vein, [28] observed that awareness campaigns positively impacted both the likelihood and depth of community involvement in watershed management initiatives. In terms of the extent of participation, this study also found that being aware was associated with a decreased level of engagement, further supporting the notion that awareness alone does not guarantee active or sustained participation.

The study focused on two categories of water resources management actors: state and non-state actors. The double hurdle regression results revealed that state actors significantly and positively influenced the decision to participate in water resources management, suggesting that affiliation with government bodies or exposure to their programs increases the likelihood of engagement among small-holder water users. This is attributed to state actors' role in providing education, raising awareness, and facilitating mobilization through structured interventions. However, the findings contradict recent studies such as [29], who found that bureaucratic inefficiencies and weak community trust limited the impact of state actors on participation in rural Tanzania. Similarly, [30] noted that many water user associations remained dormant or poorly coordinated, thereby failing to influence management practices. Furthermore, in the second hurdle of the model, the study found that state actors did not significantly influence the extent of participation, indicating that while they may encourage initial involvement, they often lack mechanisms to sustain long-term engagement in water governance processes.

Involvement in decision-making was anticipated to influence both the decision to participate and the extent of participation in water resource management. However, the double hurdle regression results revealed that while decision-making involvement did not significantly influence the initial decision to participate, it had a strong positive effect on the extent of participation. This indicates that households involved in decision-making processes are more likely to engage deeply in water governance activities compared to those excluded. This could be attributed to the sense of ownership and empowerment that comes with having a voice in key decisions, which in turn motivates continued and meaningful engagement. These findings are consistent with recent studies such as by [31], who found that inclusive decision-making significantly enhanced the intensity of participation in community-managed water schemes in Eswatini. Similarly, [32] observed in rural Tanzania that households actively involved in planning and allocation discussions were more likely to attend water management meetings and contribute to implementation efforts.

Moreover, land size was found to significantly influence the decision to participate in water resource management. The results indicated that as household land size increases, so does the probability of participating in water governance initiatives. This positive relationship may stem from the fact that households with larger landholdings are more likely to rely on irrigation and other water-dependent agricultural practices, thereby increasing their incentive to engage in resource

management. These findings are supported by recent studies such as [33], who reported that landholding size was a key predictor of farmer engagement in irrigation governance in southern Tanzania. Likewise, [34] found a positive association between land size and participation in collective water management activities in semi-arid regions of East Africa. However, in the second hurdle of the model, the study revealed that land size did not significantly influence the extent of participation. This suggests that while land size may drive initial participation decisions, it does not necessarily determine the depth or frequency of engagement in water-related activities.

4. Conclusion & Recommendations

For the case of decision to participate and the extent of participation, households participated due to the influence of age, marital status, education level, primary occupation, involvement in more than one activity, household size, awareness, water resources management actor, decision making and land size that were statistically significant in all levels of 1%, 5% and 10% thus influenced both decision to participate and the extent of participation in water resources management. Other factors, including sex, income, information dissemination and land ownership, were found to be statistically insignificant and so that did not influence both decisions to participate and the extent of participation. The study concluded that, on the large scale there is a need to create more awareness and provide enough education so as to make household informed for making participation easier.

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Conflicts of Interest

The authors disclosed that they have no conflicts of interest related to the publication of this paper.

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