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Gender differences in rice production participation among smallholder farmers in small-scale irrigation schemes in mbarali district, Tanzania

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ABSTRACT

Smallholder farmers are crucial to agri-food production in sub-Saharan Africa. However, gender disparities in rice production participation persist in Tanzania. Existing research has yet to fully explore how demographic and socioeconomic factors influence gendered participation in rice production. This study assesses gender differences in rice production participation patterns among smallholder farmers and identify gender-related socio-economic and demographic factors influencing differences in participation within small-scale irrigation schemes in Mbarali District. Using cross-sectional approach, data were collected from 397 randomly selected farmers through structured questionnaire and analyzed with descriptive and inferential statistics, including ordered probit regression. The results revealed significant gender differences in rice production participation ($p < 0.01$). Male farmers had higher participation rates in activities such as land preparation, seedbed preparation, seedling management, irrigation, herbicide, fertilizer, pesticide application, harvesting, transporting, storage, and selling, while female farmers had higher participation rates in transplanting and weeding. The overall level of participation was moderate, with 78 % of male farmers and 49 % of female farmers. However, larger proportion of females (43 %) were at a lower participation levels compared to only 1 % of male farmers, while 21 % of males and 8 % of females were at high participation levels. Factors like household size, farming management, hierarchical position within households, decision-making power, and the ability to access irrigation water positively influenced participation levels, while land size cultivated had a negative impact ($p < 0.05$). These were gender-related socio-economic and demographic factors that disadvantage female farmers' participation ($p < 0.05$). While the age of the farmer and inadequacy of irrigation water significantly affected participation levels, farm-hired labour had positive influence, however, these factors were not gender-specific. The study concludes that gender differences in participation in rice production are influenced by demographic and socio-economic factors. To address these, the study recommends for interventions that reduce gender disparities by promoting equality in resource access, enhancing women's decision-making power over resources and ability to access irrigation water, and ensure sufficient water in small-scale irrigation schemes. The government should create an enabling environment that supporting female farmers in small-scale irrigation schemes for broader gender equality in agriculture and rural development.

1. Introduction

Agriculture is a major driver of the economies of the most developing countries. It contributes to the growth of GDP and poverty reduction and provides employment opportunities to millions of men and women [1–3]. However, agriculture remains a gendered activity, and the disparities in the participation in production between men and women in this sector have been a persistent gender concern. In most cases, women have less access to productive resources and are less involved in the decision-making process [4–6]. Men have been dominant in cash and high-value crops and resources like land and irrigation water, control income, and benefits [5,7–10]. The contributions of women in this sector are often undervalued and linked to their traditional gender roles, the types of crops they grow, the labour they provide, and the time they spend in production activities [11–13]. In most cases, women are considered less capable of performing certain agricultural activities [14, 15]. Notwithstanding this, the participation of women in agriculture is still significant. They account for 40 % of labour force in this sector

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globally [16] and contribute to approximately 40 % of agricultural GDP in Africa [17]. In countries like Malawi, Tanzania, and Uganda, their labour share in crop production is exceeds 50 % [18,19]. Tanzania in particular, 81 % of women are involved in agriculture, compared to 73 % of men, in rural areas, the number jumps to 98 % [20]. Women also play a significant role in rice production globally [21]. For instance, in Pakistan, their participation increased land productivity and technical efficiency [22]. However, their participation in rice production varies across regions. This disparity underscores the need for understanding gendered participation patterns in rice production to address these existing gender inequalities to enhance women's roles in agriculture, which could improve food security and economic outcomes.

Rice plays crucial role in global food security, economic growth, employment, and the livelihoods of millions of people in developing countries [23,24]. It is a staple food for half of the global population and provides 20 % of the world's dietary energy, which is higher than that of wheat and maize [25]. In sub-Saharan Africa, rice is one of the five most important cereal crops, along with maize, wheat, millet, and sorghum [26]. Smallholder farmers are the primary rice producer in Latin American countries, Asia, and Africa under small-scale system [27–30]. For example, in Tanzania, smallholder farmers produces approximately 90 % of total rice in the country in small farms with an average of land size of 1.3 ha [21]. Climate change poses challenges to smallholder farmers who mostly grow rice under rain-fed conditions because of unpredictable and unreliable rainfall. Small-scale irrigation has proven effective in mitigating risks association with climate change [31].

Several studies conducted in Southern Asia and Africa have shown that there are significant disparities in participation of men and women in rice production. These differences are observed in various aspects such as participation in production activities, decision-making processes, labour, and resource access [11–13,32]. For instance, in Burkina Faso, Côte d'Ivoire, Madagascar, and Sierra Leone, men are more involved in production activities and dedicate more time to labour than women [11]. Similarly, southern Ghana, men dominate land preparation, weeding, spraying, and harvesting activities, while women are mostly involved in transplanting, harvesting, winnowing, milling, packaging, and marketing [10]. In Nepal, women mostly participate in less skilled activities such as transplanting, uprooting, weeding, harvesting and have low participation in decision-making while men are more involved in land preparation, pesticide application, marketing, threshing, and decision-making [13]. In Sindhudurg, India, women actively participate in rice production, but their contributions are not always recognized [12]. These dynamics reflect inequalities in participation in rice production. Traditional gender roles have historically defined men's and women's roles in rice production activities. Cultural norms also contribute to this phenomenon [33].

Numerous studies, including those by Masamha et al. [34], 1Nnaji et al. [35], Obayelu et al. [36], Mossie et al. [37], Pattnaik and Lahiri-Dutt [38], Chakma et al. [39], Sallawu et al. [40], Yee and Man [41], and Bosompem et al. [42] have identified several factors that influence farmers' participation in agricultural production. These factors including demographic, social, economic, cultural, institutional, infrastructural, and structural factors. For example, studies by Yee and Man [41] and Damisa et al. [43] revealed that female farmers' participation level in agricultural production influence by their the demographic and socioeconomic characteristics. Studies by Refs. [9,44,45] found that women's participation influenced by household agricultural decision-making, farming experience, marital status, and education. Conversely, household size, farm income, and farm size influence men's participation [44]. Land ownership, institutional support, education attainment, and access to irrigation technology training have all been identified as critical factors for women's participation in Egypt [46]. Bosompem et al. [42] found that extent of participation of smallholder farmers were influenced by farmers' gender, household size, and market information. In Bangladesh, age, agriculture knowledge, and farming experience had a positive relationship with women's participation in rice farming activities [39]. However, the influence of gender is evolving and differ across various contexts and areas. Therefore, it is crucial to understand the extent to which men and women participate in rice production in order to determine factors associating with their differences in participation in rice production particularly in small-scale irrigation schemes.

Tanzania is one of the major rice producing countries in Africa, ranking second in Sub-Saharan Africa and first in East Africa [21]. For decades, rice has been contributing to national food and nutrition security, socio-economic development, and foreign exchange earnings [21]. Rice is predominantly grown under a small-scale system by smallholder farmers [21,27–29]. Several studies have been conducted in Tanzania regarding gender and agriculture, including those by Refs. [34, 47–50], among others. However, these studies did not provide a thorough gender analysis in small-scale rice irrigation schemes. A study by Ref. [49] in the Mbarali and Kyela Districts of the Mbeya Region reported the influence of gender in rice productivity in the study area. Nonetheless, the extent of which male and female farmers participate in rice production and their gender-related factors associated with their participation remain unclear. This study aims to address this knowledge gap. Mainly, this study aimed to address the following three research questions. (i) What are the gender patterns in the participation of male and female farmers in various rice production activities? (ii) How do participation levels differ between male and female farmers in rice production? and (iii) How do demographic and socio-economic factors influence gendered participation in rice production among smallholder farmers in small-scale irrigation schemes in Mbarali District, Tanzania? aims to determine the gender-related socio-economic and demographic factors associated with their participation in rice production.

This paper contributes to the literature on gender and agriculture by providing insights into gender pattern in rice production within small-scale irrigation schemes. It also presents empirical evidence on gender differences in the participation of smallholder farmers in rice production. The paper sheds light on the impact of demographic and socio-economic factors on farmers' participation in rice production and identifies gender-related factors that affect participation of female smallholder farmers in small-cale irrigation schemes. By understanding gender differences in rice production participation, policymakers can address gender-related issues in small-scale irrigation schemes. The paper is divided into three sections: "Methodology" which describes the study methodology, "Findings and Discussion" which presents and discusses the study findings, and the last section includes the study conclusion and recommendations are presented in the last section, which also presents the policy implications.

2. Methodology

2.1. Description of the study area and research design

The study was conducted in Mbarali District, Mbeya Region, Tanzania, where rice is the most widely grown cereal crop. The district is situated between latitudes 7° and 9° south of the Equator and longitudes 33.8° and 35° east of the Green Meridian, with a rainfall season from December to April [51]. The annual mean of rainfall ranges from 450 to 650 mm. District has favourable irrigation ecosystems and agro-ecological characteristics suitable for rice farming, Over half of its potential area for irrigation in the district has already been used. The district is among the top rice producers in Tanzania and rice is mainly produced by smallholder farmers [51]. A cross-sectional research design was adopted for this study. The design was chosen because allows gathering data from a diverse group of individuals at a single point in time, facilitates comparative analysis within the same timeframe [52], and provides a snapshot of the outcome and the characteristics associated with it [53]. Under this study the design has ability to capture a comprehensive snapshot of gender differences in rice production participation within a specific context of small-scale irrigation schemes.

By collecting data simultaneously at a single point in time, the study informed the current state of gender disparities in rice production and participation levels, and correlations between gender and socio-economic and demographic factors influencing participation levels. This design, however, does not establish causality (cause-effect relationships) [53] but offers the opportunity to establish baseline data on gender participation in rice production with small-scale irrigation schemes. Such data is essential for informing immediate policy decisions and targeted interventions for gender equality. The data can also serve as a reference point for future studies that may adopt longitudinal designs to explore changes over time.

2.2. Sampling procedure and sample size

The study population comprised 42,592 smallholder farmers in Mbarali district who had benefited from small-scale irrigation schemes. The study used both non-probability and probability sampling procedures. Mbarali District was chosen from seven Mbeya region districts using the non-probability sampling method due to its prominence in rice production, irrigation system, optimal number of small-scale irrigation schemes, and the role of gender in rice production [49,51,54]. In addition, rice provides district revenues, food, and it is a leading source of households' income [51,55]. A random sample approach was used to choose respondents from three randomly sampled small-scale irrigation schemes. The sample size was 397, drawn from 42,592 farmers, and calculated using the Yamane formula with a 95 % confidence level and a precision of 0.05 [56]. A stratified proportional sampling formula was used to generate proportionate samples from the three schemes chosen: Majengo, Mbuyuni, and Mwendamtitu.

2.3. Data collection

The study used a quantitative method to collect data from respondents via face-to-face interviews using a pretested structured questionnaire. To improve the reliability and validity of data collected and self-reported that may be subject to response biases like social desirability bias or recall bias, the questionnaire was carefully designed to minimize these effects. The introduction of the questionnaire clearly stated the purpose of the survey. The purpose of the survey was clearly explained to the respondents. Krosnick [57]emphasized that the initial items on a questionnaire are critical in influencing respondent willingness to participate; they should be relevant to the survey topic, capture interest, and minimal response effort. To ensure anonymity and confidentiality during data collection and to reduce the likelihood of respondents feeling compelled to provide socially desirable answers. The questionnaire was pretested during the pilot study to identify potential issues with question clarity and response options. Pretesting helps identify questions that individuals understand and are likely to respond to Ref. [58]. The questionnaire was refined using pilot testing feedback before the actual data collection. Data were collected through structured questionnaires that administered by trained enumerators. The enumerator training was done to ensure non-leading and unbiased conditions during the survey. The trained enumerators participated in pilot study and pretesting questionnaire to capture inter-temporal variations and build rapport with farmers. The survey was conducted through in-person interviews with the selected respondents. The interviews were done in neutral and non-judgmental conditions to ensure respondents felt comfortable and provided honest and accurate information.

Primary data collected includes demographic and socioeconomic information of farmers, as well as their as their involvement in rice production. Socio-demographic variables collected include sex, age, level of education, marital status, and farmer's position in household head. According to Quisumbing and Doss [59], demographic characteristics of individuals engaged in agriculture have an impact on their participation in agricultural production as well as access to resources. The study collected data on farmers' participation in rice production using a Likert-type scale with five assigning scales. The scales were used to mask variation in participation rates that could not be represented by yes/no responses. The response scores were given as follows: 5 = very high, 4 = high, 3 = moderate, 2 = low/minimal, and 1 = not participate. The study examined seventeen different activities: land preparation, seedbed preparation, seedling management, bund-making, transplanting, irrigation, weeding, fertilizer, herbicide, pesticide applications, bird scaring, harvesting, transporting, storage, processing, and selling. The data collection procedure assured privacy, confidentiality, and respect for the participants' rights. Data was collected between May and June 2022.

2.4. Data analysis

The smallholder rice farmers in small-scale irrigation schemes served as the unit of analysis for this study. Two types of data analysis were conducted: descriptive statistics and inferential statistics using the Statistical Package for the Social Sciences (IBM SPSS version 26) and Stata 15 software was used to estimate the parameters of an ordered Probit model. The descriptive statistics analysis was conducted using percentages, indices, means, and standard deviation. Inferential statistics analysis consists of t-tests, chi-square statistics, and an ordered Probit regression model. The demographics and socio-economic characteristics of farmers were described using frequency and percentage. To determine the participation rates of male and female farmers in different rice production activities, the mean participation scores for each activity from responses obtained in five-point Likert-type scale were computed and subjected to t-tests. The *t*-test statistics used to compare the mean participation scores for each of seventeen activities by gender to establish gender pattern in participation in rice production activities. To determine the farmers' participation levels in rice production, the Participation Index (PI), mean, and standard deviation were utilized. First, the Participation Index (PI) was calculated from participation scores obtained from five-point Likert-type scale using the formula below:

$$PI = \frac{Tscore}{Maxscore} \text{ x } 100 \quad (1)$$

Where.

PI= Participation Index;
Tscore = Total score obtained;
Maxscore = Maximum possible score.

Second, the mean and standard deviation (SD) were computed from participation indices. Third, the participation levels were categorized into three levels as low, moderate, and high in these ways: Low: PI $<$ Mean – SD; Medium: Mean - SD $\leq$ PI $\leq$ Mean + SD; and High: PI $>$ Mean + SD. Several researchers like (Tadesse et al., 2020; Seged, 2023) have also used the participation index to categorize participation levels into low, medium, and high levels.

To identify gender-related socio-economic and demographic factors associated with male and female farmers' participation levels in rice production, two steps of analysis followed. First step, an ordered Probit Regression analysis employed to estimate factors influencing participation levels among smallholder farmers from the selected explanatory variables shown in Table 1. Second step, the Chi-square and independent t-tests analysis was used to uncover gender-related socio-economic and demographic factors from the factors influencing farmers' participation levels estimated in the ordered probit model. Whereas the chi-square test was used to understand the associations between dummy predictor variables and gender, while an independent T-test was used to test for the significance differences in continuous predictor variables influencing participation levels and gender.

Table 1
Description and measurement of explanatory variable used in the probit model.

S/n	Variable	Description	Measurement	Expected Relationship
X_1	Age	Age of the farmer	Continuous (age in years)	±
X_2	Farming experience	Farmer's rice farming experience	Continuous (rice farming years)	+
X_3	household size	Number of members in farmer's household	Continuous (Number of persons in household)	+
X_4	land size cultivated	Total land size the farmer grows rice in the scheme	Continuous (acres)	±
X_5	Education status	The education status acquired by the farmer	Dummy (1 = Formal education; 0 = otherwise)	+
X_6	Land ownership	Farmer's land ownership status in the scheme	Dummy (1 = Owned; 0 = otherwise)	+
X_7	Farming management	Farmer's management approach in rice production	Dummy (1 = Jointly; 0 = separate)	+
X_8	Farmers' hierarchical position in household	Farmer's position as the head of the household	Dummy (1 = household head; 0 = otherwise)	+
X_9	Hired labour access	Use of Hired labour in rice production	Dummy (1 = Yes; 0 = No)	+
X_{10}	Decision-making power over plots	Farmer's autonomy in decision on plots uses in the schemes	Dummy (1 = Yes; 0 = otherwise)	+
X_{11}	Irrigation water inadequacy	Famers received inadequate irrigation water	Dummy (1 = Yes; 0 = No)	–
X_{12}	Other sources of income	Farmer with other sources of incomes apart from rice	Dummy (1 = With other sources; 0 = otherwise)	+
X_{13}	Ability to access irrigation water	Farmer's ability to access irrigation water	Dummy (1 = With ability; 0 = otherwise)	+
X_{14}	Membership in scheme association	Farmer's membership in the irrigation scheme association	Dummy (1 = Yes; 0 = otherwise)	+

2.4.1. Model specification

Various models have been employed to investigate the factors influencing farmers' participation in agricultural production, including ordinal regression models, multinomial regression models, and binomial regression models [60–64]. Since the dependent variable of this study namely "level of participation of farmers" was an ordinal that takes three values with ordered categories of participation levels (low, moderate, and high) and these categories had natural order. The ordinal regression models both ordered logit and probit were suitable for these situations and yield similar inferences [65,66]. However, the ordered probit model was chosen to determine socio-economic and demographic factors influencing the participation levels of farmers in rice production because of the standard normal distribution of the error terms against the logistic distributions of the error terms in the ordered logit regression model [3, 67]. This model is also appropriate for analyzing variables where the outcomes are ranked or ordered but where the exact distance between the outcomes is not necessarily equal. In addition, the proportional odds assumption inherent in ordered probit models, allowing for the estimation of how the independent variables influence the odds of moving from one order category to another, maintaining the inherent order of the categories. For example, this model can reveal how household size increases the likelihood of the participation of a farmer moving from low to a moderate level of participation. The ordered probit model was also chosen to this study due to its ability to handle ordered outcomes and its robustness in analyzing complex relationships between ordinal dependent variable and multiple independent variables. Several studies, including Tadesse [68] and Kiprop et al. [69], used the ordered probit model to analyze factors influencing farmers' participation in agriculture activities and collective marketing, respectively. The study by Gebremariam et al. [70] utilized the ordinal probit model to analyze the factors influencing farmers' interactions with agricultural extension.

The dependent variable of this study was namely "level of participation of farmers," with three ordered categories of 0, 1, and 2: 0 indicating low participation, 1 indicating moderate participation, and 2 indicating high participation of a latent variable Y^*.

The model was presented as follows:

$$Y_i^* = X_i\beta + \mu_i \tag{2}$$

Where.

Y_i^* = latent (unobserved) variable underlying the observed ordinal dependent variable, Y_i.
Y_i = the observed ordinal depend variable (Y_i) is determined by the thresholders of the latent variable Y_i^*.
X_i = A vector of explanatory or independent variables for the ith observation. These are variables used to predict or explain the variations in the latent variable Y_i^*.
β the vector coefficient of the respective explanatory variables X_i. The coefficients indicate the strength and direction of the relationship between the independent variables and the latent variable.
μi = error terms, follows a standard normal distribution,

The observed $Y*$ is specified in equation (3) as follows:

$$\begin{cases} 0 \; if Y_i^* \le 0, \\ 1 \; if 0 < Y_i^* \le \mu_1 \\ 2 \; if \mu_1 < Y_i^* \end{cases} \tag{3}$$

To ensure the validity of the model, a number of diagnostic tests were carried out, including Model Fitting Information, the Goodness of Fit test, the pseudo-R-squared diagnostic test, the Parallel Lines test, and the Variance Inflation Factor (VIF). The model fitting information was: 2 Log Likelihood (intercept only = 653.337, final = 391.603, chi-square = 261.734, df = 14, and Sig = 0.000), indicating the model is statistically significant at conventional levels. Goodness of fit test: Pearson: chi-square = 571.137, df = 548, Sig = 0.239, and Deviance Chi-square = 378.152, df = 548, Sig = 1.000, and a p-value of 1.000 indicates that the mode fits the data well. Pseudo R-squared: Cox and Snell = 48.3, Negelkerke = 59.1, and McFadden = 38.9, implying that the model accounts for a substantial portion of the variation in the dependent variable. Parallel lines test: null hypothesis: 2 Log likelihood: null hypothesis = 391.603 and general = 373.826, chi-square = 17.775, df = 14, and sig = 0.217. This test assesses the proportional odds assumption, a key assumption of the ordered probit model. The Chi-square statistic compares the fit of the model with the assumption of parallel lines to a model without this assumption. With a p-value of 0.217, the null hypothesis of a parallel line is not rejected, indicating that the proportional odds assumption holds. The Variance Inflation Factor (VIF) was utilized to verify the existence of multi-collinearity among explanatory variables. It revealed that all VIF values were below 5 (VIF<5), indicating multicollinearity is not a significant concern among the explanatory variables (Pires & Rodrigues, 2007). The VIFs for each explanatory variable are shown as follows: age of the farmers (1.737), education status (1.283), land ownership status (1.917), farming experience

(1.495), membership in scheme associations (1.866), farming management (1.326), household size (1.155), total land size cultivated (1.256), farmer's position in the household (1.687), hired farm labour (1.156), decision-making power on plot usage (1.616), irrigation water inadequacy (2.734), other sources of income (1.136), and ability to access irrigation water (3.022). The coefficients in the ordered probit model are used to explain the direction of predictors on participation levels.

2.5. Study limitations

This study utilizes a cross-sectional design to examine gender differences in rice production participation among smallholder farmers in small-scale irrigation schemes. This design provides a snapshot of the current state of gender participation patterns and identifies associations between variables. However, this design lacks the ability to capture changes over time and establish causality. Participation patterns may evolve due to factors like seasonal variations, household dynamics, and changes in access to resources. A cross-sectional design cannot account for these temporal variations, leading to an incomplete understanding of how gender differences in participation might change over time. The design cannot definitively determine whether certain socio-economic or demographic factors cause observed differences. To address these limitations, future studies should employ longitudinal studies, which track changes over time, to better capture the evolution of participation patterns and establish causal-effect relationships.

The study uses quantitative methods and a structured questionnaire, which may limit understanding of socio-cultural and gender norm factors affecting gendered participation in rice production. Future studies could benefit from incorporating mixed methods involving quantitative and qualitative approaches, like focus group discussions or interviews, to enhance the accuracy and depth of the findings.

3. Findings and Discussion

3.1. Descriptive statistics of smallholder farmers

The descriptive statistics presented in Table 2 for selected demographic and socio-economic characteristics of sampled rice farmers were disaggregated by gender. The majority of respondents were male, indicating a dominance of males in rice farming in small-scale irrigation schemes. The average age of males was 47 years, slightly higher than of females, while that of females was 46 years. Female farmers had more experience over 15 years in rice farming compared to male farmers, who had 14 years. The average household size of male farmers was six members, and that of female farmers was five members, suggesting more labour availability in male farmers' households. Atube et al. [71] claimed that household size is a key indicator of labour availability. Over 84 % of male farmers owned land and cultivated an average of 3.49 acres, compared to 68 % of female farmers who owned land and cultivated an average of 2.45 acres. Many male and female farmers had formal education; however, there were more female farmers (14.4 %) compared to 9.3 % of female farmers who did not attend formal education. This is consistent with previous studies showing female farmers are more illiterate, such as Joshua and Omahas [72]. All male farmers were heads of households and only 33.1 % of female farmers had headship, reflecting the patriarchal cultural system of Africa, where male-headed households dominate productive resources.

Many male farmers (70.9 %) engaged in joint farming management with their spouses, compared to 43.2 % of female farmers. Only 27.1 % of male and 31.1 % of female farmers had used hired labour on their farms, but a higher number of females with hired farm labour could be potentially due to unmechanized farm female-related activities like transplanting and weeding in the study area [73], hence the additional labour required. Male farmers (67.8 %) had more decision-making power over plot usage than female farmers (48.9 %), who had similar power. Most farmers, both male and female (66.7 % and 73.4 %, respectively), had access to insufficient irrigation water on their plots. However, female farmers faced more difficulties in securing irrigation water. More male farmers (66.3 %) compared to female farmers (48.9 %) had the ability to access irrigation water. This finding is consistent with a study by Bryan and Garner [74], which also found women encounter difficulties in getting irrigation water.

Most farmers, both male and female, have additional income sources, with female farmers having slightly higher proportions, indicating that female rice farmers have diverse revenue streams for financial resilience. Most male farmers (61.2 %) were members of the scheme association, compared to 46.8 % of female farmers. This indicates that male farmers are more likely to benefit from the opportunities available in small-scale irrigation schemes. Kiprop et al. [69] highlighted the importance of group membership in resolving common farmer issues.

Table 2
Descriptive statistics results for demographic and socio-economic characteristics of smallholder farmers.

Variable	Male (N = 258)		Female (n = 139)	
Continuous variable	Observations	Mean	Observations	Mean
Age of the farmer (year)	258	46.50 (11.63)	139	46.41 (11.89)
Farming experience (years)	258	14.19 (9.14)	139	15.96 (10.06)
Household size	258	6.13 (2.16)	139	5.08 (2.04)
Land size cultivated (acres)	258	3.49 (2.40)	139	2.45 (0.21)
Categorical variable	**Frequency**	**%**	**Frequency**	**%**
Education status				
Acquired formal Education	234	90.7	119	85.6
No formal Education	24	9.3	20	14.4
Land ownership in the scheme				
Own land	219	84.9	95	68.3
Not own land	39	15.1	44	31.7
Farm management				
Jointly with spouse	183	70.9	60	43.2
Separate	75	29.1	79	56.8
Farmers' hierarchical position				
Household head	258	100	46	33.1
Not household head	0	0.0	93	66.1
Hired farm labour access				
Yes	70	27.1	46	31.1
No	188	72.9	93	66.9
Decision-making power				
Yes	175	67.8	68	48.9
No	83	32.2	71	51.1
Irrigation water inadequacy				
Yes	172	66.7	102	73.4
No	86	33.3	37	26.6
Other sources of income				
Yes	232	86.4	129	92.8
No	35	13.6	10	7.2
Ability to access irrigation water				
Yes	171	66.3	68	48.9
No	87	33.7	71	51.1
Membership in scheme associations				
Member	158	61.2	65	46.8
Not a member	100	38.8	74	53.2

The numbers in parentheses are standard deviations.

3.2. Gender pattern in participation in rice production activities

The findings in Table 3 presents a gender pattern of participation mean scores between male and female farmers across seventeen rice production activities. The study found male farmers had higher mean participation scores than female counterparts nearly all activities and the differences were highly statistically significant ($p < 0.001$). These activities land preparation, seedbed preparation, seedling management, bund-making, irrigation, herbicide applications, fertilizer application, pesticide application, bird scaring, harvesting, transporting, storage, and selling compared to female farmers. However, there are few activities in which female farmers had higher mean participation scores. These activities include transplanting, weeding, paddy drying and processing. Yet statistically significant differences ($p < 0.001$) observed in two activities only: transplanting and weeding. This indicates gender disparities in participation, with male dominating in rice production activities. These findings are consistent with previous studies [75–77], who found a similar pattern of male dominance in field preparation activities, plant protection and field management, harvesting and post-harvesting operations, and marketing management. Similarly, Mushi [78] and Jambo et al. [79] found that men dominated irrigation in small-scale irrigation schemes in Tanzania and Ethiopia, respectively. This is however, in contrast study conducted in Bangladesh by Chakma et al. [39], which indicated that women were more involved in activities connected to harvesting, harvesting, and post-harvesting. This contradiction may be attributed by gender roles dynamics which varies across various contexts and areas [59]. In African rice farming, male-dominated tasks [11]. This also could be a plausible explanation for the higher participation mean scores for male farmers in many rice production activities.

The study further reveals that female farmers are more involved in manual labor-intensive tasks like transplanting and weeding, largely due to socio-cultural factors, traditional gender roles in agricultural production, low mechanization, and limited access to resources such agricultural machinery and technology. In Mbarali District, women have limited access to available agricultural machinery for land preparation and rice harvesting [73]. This may explain why men continually dominate agricultural machinery-related activities and taking up the traditional women gender roles such as harvesting due to mechanization. Additionally, Rice is both cash and food crop in Tanzania, the country is now experiencing an increase of local and external market demands of rice. Since males are more inclined to cash crops and high-valued crops [8], this may also attributed for higher participation scores in most of rice production activities of male smallholder farmers.

Table 3
The distribution of extent of the participation in rice production activities.

Activity	Means		T	P. value	Difference
	Male	Female			
seedbed preparation,	4.965	3.518	13.445	0.000	M***
seedling management	4.981	3.612	12.836	0.000	M***
Land preparation	4.934	3.604	12.183	0.000	M***
Bund-making	4.915	3.166	14.362	0.000	M***
Transplanting	2.291	4.425	−12.947	0.000	F***
Irrigation	4.802	2.741	17.215	0.000	M***
Weeding	1.992	3.914	−11.293	0.000	F***
Herbicide application	3.919	1.410	16.225	0.000	M***
Fertilizer application	4.240	2.518	10.669	0.000	M***
Pesticide application	2.861	1.403	7.927	0.000	M***
Bird scaring	1.597	1.151	3.515	0.000	M***
Harvesting	4.996	3.496	13.299	0.000	M***
Paddy drying	2.694	2.719	−0.136	0.892	F
Transporting	4.954	3.482	11.872	0.000	M***
Storage	4.783	3.770	8.278	0.000	M***
Processing	1.853	1.928	−0.455	0.650	F
Selling	4.593	3.842	7.254	0.000	M***

M *** symbolizes mean participation score for male greater than those for female at 1 % significance level, F *** symbolizes mean participation score for female greater than those for male at 1 % significance level respectively.

3.3. Gender pattern in participation levels in rice production

The findings in Fig. 1 presents gender pattern in participation levels among farmers in rice production. The findings showed that one percent (1 %) of males were in low level compared to 43 % of females. Higher proportional of males over three-quarters and one-fifth were in moderate and high participation levels, respectively while less than fifty percent of females were in moderate level and 8 % in high level. The finding indicate that female farmers are underrepresented in moderate and high levels participation. Similarly, Chakma et al. [39] found that women in Bangladesh had low level of participation in irrigated rice production. The findings are also similar to those by Nakazi et al. [80] and Nwaobiala et al. [44] who observed differences in level of participation in agricultural activities between women and men. This could be attributed by several factors including limited access to resources, traditional gender roles, societal expectations which often exclude women from skilled agricultural tasks, male-dominance in high valued crops, limited access to education and training, and time constraints. Women are often bear the responsibility of household chores, childcare, and other domestic duties, which may limit their time available for agricultural work.

3.4. Gender-related factors in Farmer's participation levels in rice production

The study explored gender-related factors associated with the influence of participation levels of farmers in rice production. An ordered logistic regression model was used to determine factors influencing participation levels. Independent T-tests and Chi-square tests were employed to uncover gender-related factors associated with differences in participation levels. Table 4 shows that nine of the fourteen factors estimated in the model had significant influence on farmers' participation levels. Three factors including age, land size cultivated, and inadequate irrigation water negatively impacted participation levels, showing that these factors are related to lower participation levels. Six factors including household size, Farmers' hierarchical position in household, farm management, farm-hired labour, decision-making power, and ability to access irrigation water positively impacted participation levels. This implying that these factors are associated with increasing participation levels. These results align with study by Ndlovu et al. [63] who found age and access to irrigation reduces level of participation and marital status increases level of participation. The findings further revealed six gender-related factors among nine factors that found to influence participation levels as shown in Tables 5 and 6. These factors were household size, land size, Farmers' hierarchical position in household, farm management, decision-making power, and ability to access irrigation water.

The age of the farmer showed a negative and significant coefficient ($p < 0.01$), indicating that farmers' level of participation in rice production declines with age. As a farmer grows older, their likelihood of participating decreases. This could be due to physical limitations and the risk-averse character of older farmers, who are less adaptable and unwilling to change their traditional farming practices. The *t*-test results in Table 5 revealed no significant differences in mean ages between males and females ($p > 0.05$), showing that age was not a gender-related factor. The implication is that gender differences in participation levels among farmers in rice production in the study area were not attributed to their age. This means that both male and female farmers their participation affected as the grows older. This is in line with a study by Ola [81] that found a negative relationship between age and women farmers' participation in rice production, but contradicts other earlier studies, such as Mossie et al. [37] and Chakma et al. [39], which found positive relationships between participation in rice production and

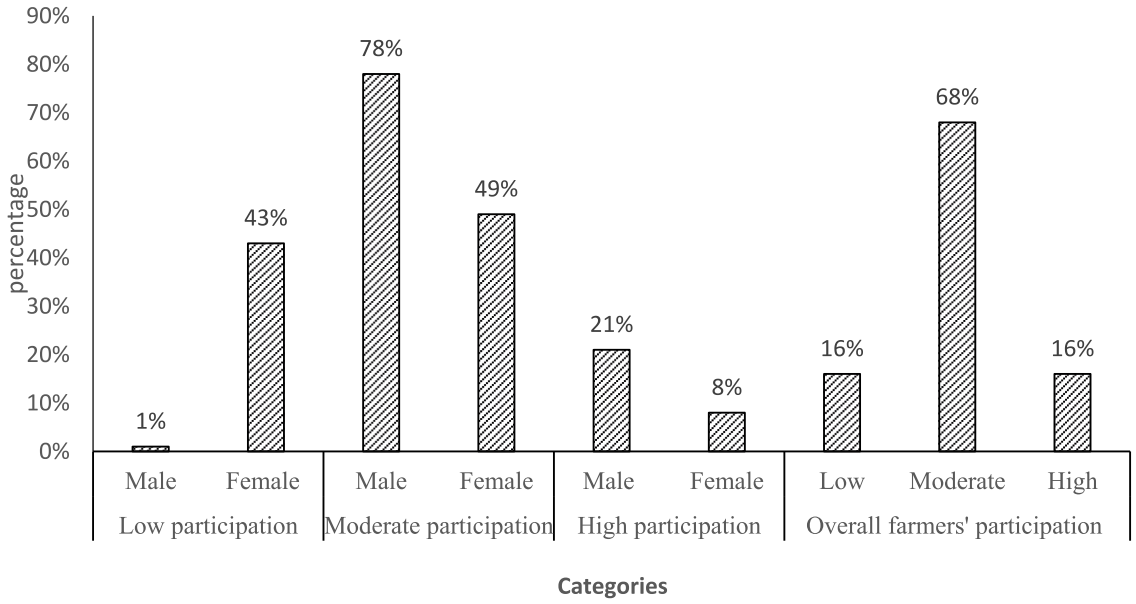

Fig. 1. Gender Differences in Participation levels between male and female in rice production.

Table 4
Ordered probit regression analysis results on factors influencing farmers' participation level in rice production.

Variables	Coef.	Std. Err	Z	P > |z|	[95 % Conf. Interval]	
Age	−0.028	0.008	−3.32	0.001***	−0.044	−0.011
Farming experience	0.015	0.009	1.59	0.112	−0.003	0.033
household size	0.088	0.035	2.53	0.011**	0.019	0.156
land size cultivated	−0.104	0.036	−2.92	0.003***	−0.174	−0.034
Education status	0.235	0.256	0.92	0.358	−0.266	0.737
Land ownership	0.000	0.237	0.00	0.999	−0.465	0.465
Farming management	0.630	0.170	3.70	0.000***	0.297	0.963
Farmers' hierarchical position in household	2.876	0.308	9.34	0.000***	2.273	3.479
Hired labour access	0.379	0.164	2.32	0.020**	0.059	0.700
Decision-making power over plots	0.449	0.185	2.43	0.015**	0.087	0.812
Irrigation water inadequacy	−1.053	0.252	−4.17	0.000***	−1.547	−0.558
Other sources of income	0.275	0.234	1.18	0.239	−0.183	0.733
Ability to access irrigation water	1.182	0.255	4.63	0.000***	0.682	1.682
Membership in scheme association	−0.099	0.193	−0.51	0.607	−0.476	0.278
/cut 1	0.142	0.518			−0.873	1.156
/cut 2	3.593	0,572			2.473	4.714
Number of observations	**397**					
Log likelihood	**−205.964**					
LR chi2 (14)	**261.73**					
Prob > chi2	**0.0000**					
Pseudo R2	**0.3885**					

***P < 0.01, **P < 0.05.

Table 5
T-test results: gender-related factors on influencing participation levels in rice production by gender (n = 397).

Variables	Sex of the respondent	N	Mean	Std. Deviation	Std. Error Mean	T-test	P-value
Age of the farmer (in years)	Male	258	46.50	11.628	0.724	0.073	0.942
	Female	139	46.41	11.889	1.008		
Household size	Male	258	6.13	2.159	0.134	4.721	0.000***
	Female	139	5.08	2.043	0.173		
Total land size cultivated (acres)	Male	258	3.48	2.397	0.149	4.031	0.000***
	Female	139	2.45	2.531	0.214		

***P < 0.01.

farmers' age.

The coefficient for land size cultivated showed a statistically significant negative influence (p < 0.001), implying that farmers' participation levels are affected by their land size cultivated. The study also revealed a statistically significant difference (p < 0.001) between the total land cultivated by male and female farmers (Table 5). This

Table 6
Chi-square test results: Gender-related factors on the influencing participation levels in rice production by gender: (n = 397).

	Male		Female			
Variables	Frequency	%	Frequency	%	Chi-square	P-value
Farming management						
Jointly (wife or husband)	183	70.9	60	43.2	29.328	0.000***
Separated	75	29.1	79	56.8		
Farmers' hierarchical position in household						
Head of Household	258	100	46	33.1	225.426	0.000***
Not head of household	0	0.0	93	66.1		
Hire farm labour access						
With hired labour	70	27.1	46	31.1	1.552	1.29
Without hired labour	188	72.9	93	66.9		
Decision-making power on plots use						
Yes	175	67.8	68	48.9	13.602	0.000***
No	83	32.2	71	51.1		
Irrigation water Inadequacy						
Yes	172	66.7	102	73.4	1.905	0.102
No	86	33.3	37	26.6		
Ability to access irrigation water						
With ability to access	171	66.3	68	48.9	11.360	0.001***
No ability	87	33.7	71	51.1		

***P < 0.01.

implies that land size is a gender-related factor, with male farmers cultivating a larger area than female farmers. These findings also support those of Quisumbing and Doss [59] and Mosha et al. [82], who found that women farm smaller land areas. This could be attributed to the fact that the large land size requires more capital, labour, technologies, and mechanization to allow production. Therefore, increasing land area without facilitating women access to capital, mechanization and female-friendly technologies may continue to affect their participation level and making larger-land farming more challenging for them.

The coefficient of household size was positive and significant ($p < 0.05$), showing that larger household size is associated with higher participation levels. The implication is that farmers from larger households are more likely to have higher participation levels, which aligns with the findings of Sallawu et al. [40], which found that participation in farming increases the number of household members. The study also found a strong statistically significant difference ($p < 0.001$) between the household size of male and female farmers, indicating that household size is a gender-related factor associated with higher participation levels. The findings further show that the mean household size of male farmers is significantly larger than that of female farmers, indicating that male farmers have access to more labour resources within their households, potentially enhancing their participation levels in rice production activities. This could explain why male farmers tend to increase their participation level in rice production compared to their female counterparts. Geddafa et al. [83] also claimed that larger households have more workers, which could contribute to an increase in farmers' participation in production activities.

Farmers' hierarchical position in households showed a significant positive coefficient ($p < 0.001$), indicating that headship in household is strongly influence participation levels. This means that farmers, who also lead households, have higher levels of participation. Table 6 shows a statistically significant association ($p < 0.001$) between a farmer's gender and hierarchical position in the household with 100 % of male farmers holding household headship compared to 33.1 % of female farmers. This factor is also gender-related favoring male farmers in higher level of participation than female farmers. This might be the result of societal norms that grant men, who often head households, more authority over resources, the ability to make decisions, and access to social services [84]. The statistically significant positive coefficient of farming management ($p < 0.001$) suggests that farmers who practice joint farming have a higher participation level than those who farm alone. A strong statistically significant relationship ($p < 0.001$) was found between a farmer's gender and farming management (Table 6). This shows that farm management is a gender-related factor, with a higher percentage of male farmers engaging in joint farming with their spouses or partners (70.9 % vs. 43.2 %). A joint farming arrangement offers benefits such as shared resources, collective decision-making, and risk-sharing, potentially increasing male farmers' participation levels.

Farm-hired labour access shows a positive and significant coefficient ($p < 0.05$), indicating that it influences higher participation levels. This means that farm-hired labour boosts participation levels smallholder farmers. Furthermore, the chi-square test results showed that there was no significant association ($p > 0.05$) between farm-hired labour access and farmer gender. This suggests that farm-hired labour access was not a gender-related factor, despite more female farmers than male farmers reported using hired farm labour. This could be because small-scale irrigation schemes in the study area had not yet been fully mechanized particularly in female related activities, necessitating additional labour to reduce the burden of labour-intensive tasks like transplanting and weeding. Ankrah et al. [85] found similar findings in Ghana. Additionally, Fikirie et al. [7] emphasizes that hired labour is an essential component of irrigation agriculture activities. This finding contradicts the study by Awuor et al. [86], which found a strong relationship between gender and access to hired labor with men having more access than women.

The significant positive coefficient of decision-making power on plot usage ($p < 0.05$) implies that farmers with decision-making power on plot usage tend to have higher participation levels in rice production. This is supported by previous studies by Zakaria [87] and Peralta [84]. The chi-square test results (Table 6) showed a strong statistical relationship ($p < 0.001$) between gender and decision-making power on plots, however, male farmers have these powers. This implies that gender inequality in decision-making is existing in small-scale irrigation schemes with women are less involved in decision-making over resources and remain disadvantaged at higher participation levels. This may be attributed to traditional social customs in African societies, where men are granted authority over resources and decision-making. This is consistent with studies by Peralta [84] and Safdar et al. [88], which reported men dominating decision-making about farming resources.

Irrigation water inadequacy had a significant negative coefficient ($p < 0.001$), indicating an adverse influence on participation levels. The findings also show that there was no statistically significant association between irrigation water inadequacy and gender ($p > 0.05$), indicating that the factor is not gender-related. This means that insufficient irrigation water lowers the participation levels of both male and female farmers. Moreover, the finding implies that smallholder farmers regardless of their gender are facing constraints in accessing adequate irrigation water, hence affecting their participation in rice production and putting their production at risk. Ensuring adequate water for irrigation in the schemes for both male and female farmers is crucial to enhance their participation and livelihoods. The finding concurs with Sallawu et al. [40] observation that inadequate access to productive resources also lowers participation in agricultural activities.

The study further found that ability of farmers to access irrigation water significantly influences their participation in rice production. Positive and significant coefficient ($p < 0.001$) indicate an increasing influence on participation levels of farmers. Zemarku et al. [89] noted a similar observation. The study also revealed a strong relationship ($p < 0.001$) between gender and farmers' ability to access irrigation water. More male farmers than female farmers had this ability. This suggests

that the factor is gender-related that disadvantages female farmers in irrigation water. This is possibly attributed by gender division of labour in agricultural activities that assign irrigation activity as a traditional male gender role. This could potentially lead to males dominating in irrigation water, resulting in their higher participation levels in rice production. This aligns with a study by Bryan and Garner [74], which reported that women face limitations in acquiring irrigation water, which affects their participation in small-scale irrigation schemes.

This study is primarily focused on socio-economic and demographic factors that influence gendered participation levels in rice production among smallholder farmers. There are other factors, such as cultural factors, gender norms, and external economic conditions, that may influence gender differences in participation levels. These factors, however, were not considered in this study because of the study scope. Future studies should include these factors for a more comprehensive understanding of the determinants of participation. The findings from Mbarali District are insightful, however, and should be interpreted with caution when generalizing to areas with different agro-ecological, socio-economic, or cultural conditions. Therefore, future research should explore these dynamics in diverse settings to validate the generalizability of the results. Despite these limitations, this study offers valuable insights for researchers, stakeholders, and policymakers that they can use the findings to address gender inequality in irrigated rice production, smallholder farmers, and small-scale irrigation schemes.

4. Conclusions and recommendations

The study examines gender differences in participation of smallholder farmers in rice production within small-scale irrigation schemes in Mbarali District, Tanzania. Although both male and female farmers participate in all rice production activities, the study reveals that gender disparities in rice production participation persist among smallholder farmers within small-scale irrigation schemes in the study area. Male farmers are highly involved in land preparation, bund-making, seedbed preparation, seedling management, irrigation, herbicide application, fertilizer application, pesticide application, bird scaring, harvesting, transporting, storage, and rice selling, except for transplanting and weeding which are mostly undertaken by females. Generally, the level of participation of smallholder farmers in small-scale irrigation schemes is moderate. However, female farmers predominantly at low levels and under-represented at high levels. These inequalities are associated with socio-economic and demographic factors. The study evident that these factors have positive and negative impacts on farmers' participation levels, and most of them are gender-related factors that mostly disadvantage levels of participation of female farmers in small-scale irrigation schemes. For example, factors such as household size, hierarchical position in households, farming management, farm hired labour, decision-making power, and ability to access irrigation water positively influence participation, while age, land size cultivated, and irrigation water inadequacy negatively affect it. It is also noted that male farmers are increasingly taking up activities that were traditionally undertaken by females. These activities including harvesting because of undergoing mechanization in the district. Generally, the gender inequalities in rice production participation are high in small-scale irrigation schemes. Lower participation of female farmers and limited access to irrigation water, farm hired labour, and decision-making power may not only hamper rice self-sufficiency growth but potentially undermine overall agricultural productivity and overall rural development. Ensuring adequate water for irrigation in the schemes for both male and female farmers is crucial to enhance their participation and livelihoods. Address these disparities is essential for gender equality and enhancing the contribution of rice sector in food security, economic growth and rural livelihoods.

To address gender disparities in participation and increase participation levels of smallholder farmers in rice production. It is recommended for targeted interventions that focus on enhancing farmers access to critical resources like irrigation water and farm-hired labour with special attention to female farmers. The Mbarali Local Government Authority, District Irrigation Office, Ruaha Basin Development Authority, and irrigation scheme associations and irrigation water committees should strive to improve irrigation water availability and promote equal distribution for both male and female farmers. The district community officers and irrigation scheme leaders should promote gender-sensitive awareness campaigns to strengthen women's decision-making power over resources within households and scheme associations. Agricultural extension services should prioritize training for women in technical activities like irrigation management, seedling preparation, and herbicide application that are traditionally dominated by men. Additionally, government, non-governmental organizations, development practitioners, and other stakeholders should introduce women-friendly and labor-saving technologies in production activities like irrigation, transplanting, weeding, herbicide application, and harvesting. These interventions will help to address labour constraints, particularly for female farmers and foster their participation in production activities. Hence increase participation levels in rice production.

Policy implications

This study has significant policy implication for addressing gender disparities in the participation of smallholder farmers in rice production and the lower participation of female farmers in small-scale irrigation schemes. Policy interventions should consider gender-sensitive agricultural and irrigation policies that ensure equality in access to resources, including irrigation water, land, and farm hired labour. Additionally, policy interventions should consider implementing gender-responsive supporting programmes like irrigation systems and training programs to enable women to participate in high-value production activities, including irrigation, harvesting, and post-harvesting activities, as well as in decision-making power and farming management. This would not only promote gender equality in small-scale irrigation schemes and rice production but would also help to improve agricultural productivity and economic outcomes in rural regions.

Limitations and future research areas

The study found significant associations between socio-economic and demographic factors and the participation levels of the farmers, but we acknowledged the limitations in establishing causality because of research design adopted for this study. Future studies should employ longitudinal studies to assess how changes in household size, irrigation water access, farming management, farmers' hierarchical position, and decision-making dynamics over time influence gendered participation in rice production of male and female farmers to address the root causes of participation disparities. Additionally, the scope of this study was mainly on socio-economic and demographic factors and gendered participation. Other factors, such as cultural norms, gender norms, and external economic conditions, may influence gender inequalities in participation levels in rice production but were not taken into account in the study. Future research could integrate these characteristics to provide an expanded understanding of the factors that influence participation.

Authors' contributions

The work was conducted collaboratively among all authors, read and approved the final manuscript.

Availability of data and materials

The data used for this study are available from the corresponding author on reasonable request.

CRediT authorship contribution statement

Neema Mwalyagile: Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Data curation, Conceptualization. **John N. Jeckoniah:** Writing – review & editing, Validation, Supervision, Project administration, Conceptualization. **Raymond J. Salanga:** Writing – review & editing, Supervision, Project administration, Conceptualization.

Declaration of competing interest

The authors have declared that there are no competing interests.

Data availability

Data will be made available on request.

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