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Climate and Socio-economic Factors Affecting the Adoption of Irrigation Practices for Improved Rice Yield in Mbeya Region, Tanzania

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ABSTRACT

Rural farmers are facing different challenges, resulting from climate change and weather variability, which pose threats in crop production and productivity. Small scale farmers try to cope with the prevailing situations by adjusting to different mechanisms including adopting irrigation services. This study seeks to determine the factors influencing rice farmers' decision to adopt irrigation technology and find out the significant contribution of irrigation to rice yields in the Mbeya Region of Tanzania. Data were collected through structured questionnaires, interviews, and focus group discussions. Data analyses were performed by using descriptive statistics, logistic regression, and ordinary least square (OLS) regression by STATA (v13). The descriptive statistics characterized households' socio-demographic and economic characteristics. Logistic regression results affirmed that households' education, labor size, meteorological information, access to financial services, extension services and previous farm outputs significantly influenced irrigation adoption by farmers. Results from OLS regression confirmed that irrigation significantly contributed about 3.2 % to rice yield at P>0.05 level. The study recommends the adoption of irrigation technology in Tanzania as means of coping strategy to the negative impact of climate change and weather variations.

Keywords: *adoption, irrigation, Mbeya-Tanzania, regression, weather, yield*

INTRODUCTION

The global food demand crisis is exacerbated by water pressure resulting from the impact of climate change and weather variability. Water scarcity has fueled threats to crop production as a result of weather changes (*Fan and Mccann 2017*). The major impacts of less water which reduces crop outputs are being felt by rural farmers especially in Tanzania, because their entire agriculture are rain-fed (*Iglesias and Garrote 2015*). Although population upsurge and socio-economic activities are commonly reported causes of water shortage, recent studies indicate that weather variability including the change in rainfall patterns, high temperature, and excessive sunshine is a more prominent cause as water shortage (*Yu et al. 2018*). Scholars uphold that the adoption of irrigation technology by the smallholder farmers could restrain the situation of water shortage (*Xing-guo et al. 2017; Jun et al. 2017*). For example (*Swanepoel and Hadrich 2015*) argue that the decision for adoption of irrigation technology is inevitable to most agricultural communities since water scarcity incidences are growing.

The critical negative impacts brought by drought necessitate rice farmers to adopt irrigation technology. The decision by households to adopt newly introduced technology is influenced by socio-economic, demographic, and institutional factors. The Factors that may affect adoption depends on the attitude, awareness of the present technology and information about the new technology. Therefore adoption is a decision-making process that individuals must pass through. Farmers need to have information regarding the new technology to enable them to make a proper decision on whether to accept or reject the technology. If farmers decide to accept the adoption means have decided to reap the best out of the available options to maximize their utility. For rice farmers, their utility will target optimizing yields and productivity while minimizing the negative impact of water shortage to maximize their revenues and profits. Although farmers have to choose the best irrigation practices, they are limited to financial support, technology, and land (*FAO 2018*). Smallholders make choices with regards to the available basket of alternatives (*Hunsaker et al. 2015*). For instance, the type of crops determines the style of the irrigation system as a means of water conservation (*Ndhleve 2017*). Also, farmers' expectations of reaping higher-income influence a household's decision to adopt new technology (*Tang et al. 2016*) observes that the farmers face risks in production, the more they develop adoption capability. Moreover, the availability of external supports, such as subsidies, information, and extension services are reported to increases awareness for new technology adoption (*Cremades et al. 2015*). Farmer's history and record concerning the available technology and the challenges experienced from the current technology could influence a farmer's decision of adopting similar or another counterpart technology. Based on this background, the objectives of this research were of two-fold; first, to determine factors influencing farmers' decision to adopt irrigation technology as a solution to dry spell variability impact, and second, to evaluate the contributions of irrigation technology adopted by the smallholder rice farmers on their rice yields in the region.

Empirical Model Estimation

Farmers are being challenged by the impact of weather variability, such as insufficient water, prolonged dry spell, intense sunlight, pests and diseases, which affect their farming activities leading to poor rice growth as well as reduced yields. The smallholder's farmers always have the desire to utilize the available means whether temporary or permanent so as to restrain the situations. Logistic Regression Model was used to determine the factors which influence rice farmers to adopt or not to adopt irrigation technology in the event of less moisture availability in the study region. The logistic regression has been widely used by many authors to solve the problems with dichotomous decisions (*Kulyakwave et al. 2019*). For instance, (*Ntashangase et al. 2018*) used the model successfully to determine the influencing factors for farmers to adopt Conservation Agriculture (CA) in South Africa. Also, (*Kontogeorgos et al. 2014*) used a logistic regression model to determine the decision factors for implementing a Quality Assurance System (QAS) by the cooperative. The model worked perfectly and the results indicated that the size of the cooperative, the perception of QAS, and cooperative activities were the main determinants for the degree of cooperation with QAS. Furthermore, the logistic model was used in the Zhejiang Province of China to assess factors encouraging farmers to outsource machinery. The findings revealed that land size and government subsidy factors encouraged the farmers to outsource machinery (*Ji et al. 2017*). Therefore, in this study, the logistic regression model was used to determine the choice factors that influence small scale rice farmers to adopt irrigation services in the region.

MATERIALS AND METHODS

Methods and Data Collection

This study was conducted in the two districts of Mbarali and Kyela in the Mbeya Region (**Figure 1**). Mbeya Region is located in the Southern Highlands of Tanzania. It is found between latitude 70° and 90° 31' to the south of equator and longitude 320° and 350° east of Greenwich meridian. The region is among the best

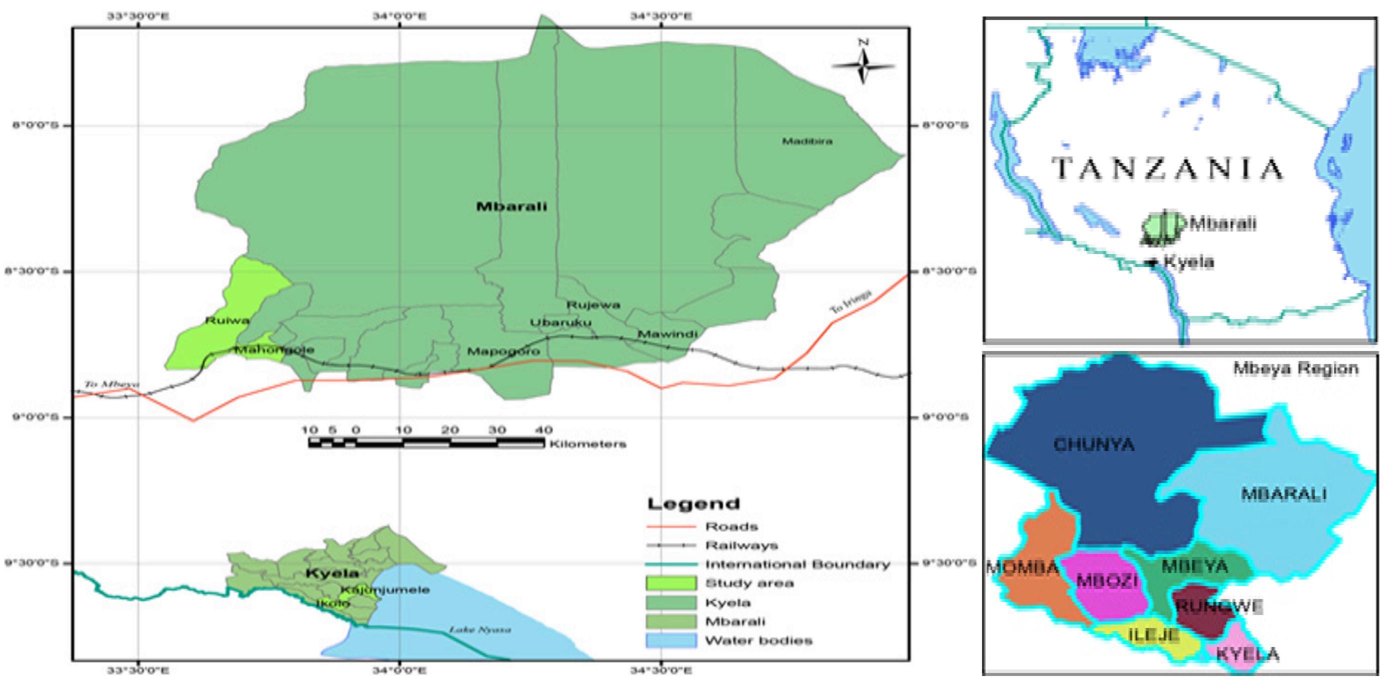

Figure 1. The map of the Mbeya region showing the study areas

regions in terms of agricultural yields in Tanzania and rice production is the major agricultural crop in the region. Mbeya is experiencing a tropical climate that contributes to the performance of crop production. Rice is mainly cultivated in the Mbarali and Kyela Districts which were the center of this study. The total area under rice production by the two districts has been on the increase from time to time, but currently, it is approximated to be above 20,500 ha. The Mbarali District is bordered with Iringa Rural District in the north, Chunya, and Mbeya rural districts to the West and south respectively.

The main activities in the districts are crop production involving rice, maize, cassava, banana, cocoa, beans, and potatoes. However, rice is largely grown in the area and is the symbol crop identifying the two districts and Mbeya Region. Mbarali receives an average rainfall ranging between 300 mm to 900 mm per annum starting from the month of December to April while Kyela District which is located in the South of the Mbeya region receives 350mm to 800 mm. The Kyela District borders Makete to the east, Ileje District in the west, and the Republic of Malawi to the south.

Mbarali District has the largest area (The Usangu Basin) accounting for almost 28% of the total area is under paddy. Rice production in the district is rain-fed production mostly conducted during the wet season. However, due to weather variations, irrigation water is used to subsidize the rain-water. The available statistics show that total irrigated land is above 40,000 ha mainly within the Usangu basin. The district's rice output contribution to the region accounts for above 60% of all total regional rice produce.

On the other hand, many households depend on paddy production where other crops including maize, beans, banana, and cassava are farmed next to paddy. In the area, livestock keeping is also practiced which is reported to cause land conflicts among farmers who compete for grazing land and cultivation area. Studies demonstrate that the mean households' rice farm size is 0.86 acres whose yield is likely to earn the farmer an average amount of Tanzania Shillings (TZS) 670742.72 (US$ 1.00 = TZS 2,290). Also, (*Ngailo et al. 2016*) pointed out that average rice yields in the district account from 1.6 to 4 t ha^{-1}, but areas with irrigated schemes recorded higher average rice yields from 4 to 6 t ha^{-1} for uplands and 6 to 10 t ha^{-1} for lowlands. On a similar view, Kyela District covers about 2% of the Mbeya Region area. The production contributes to almost 20% of the total regional rice. Apart from crop production, livestock is also another important socio-economic activity in the district. Although a total area of 450 km^2 is covered with water, irrigation technology is not developed as compared to Mbarali District, thus, rice production is solely rainfall-dependent.

Data collection was done during the 2017-18 farming season. The two districts were selected based on their performance in rice production status. Purposive sampling was used to select two wards from each district. From each ward, a random sampling technique was applied to obtain the required sample size of 240 households. To ensure successful interrogations, the author's trained enumerators who could understand and interpret the questionnaires to the respondents without distorting the required information were trained.

Since the survey was done during farming seasons, most of the household heads were interviewed in the field while they were weeding, applying fertilizers, or transplanting. The other respondents were visited in their homes for the interview. These were purposely done as the study targeted to interrogate household heads who are responsible for making the decision to adopt irrigation or otherwise. A questionnaire was used as a guide during the face-to-face interviews. The collected data were transferred into epidata and the stata software which were used for the analyses.

Analytical Techniques

The descriptive data elicited from the respondents including socio-demographic and economic characteristics, weather variables, extension and technological services, and institutional services were analyzed using descriptive statistics. Variables' counts, percentages, and means were computed and presented (**Table 1** and **Table 4**). The impact of irrigation on the rice yield was determined by regressing the rice yield. with the set of explanatory variables including the decision to adopt irrigation as the means of farmers' reaction to weather variability in the study region.

Modeling the Choice Factors for Irrigation Adoption with Logistic Regression Model

The logistic regression model is selected because it has been used successfully in different studies ending up with positive results when solving the problems with binary variables. It should be noted that in the current research, the decision of rice farmers of whether to adopt or not to adopt irrigation technology is of a binary variable. The equations take the values of 1 if the household decides to adopt irrigation services and 0 if otherwise. This indicates the possible maximum utility a farmer could obtain by choosing to adopt the irrigation

Table 1. Description of variables for Logistic Regression Model.

Variables	Variable description	Group	Observation	Mean
Households Characteristics				
Age	If household head age < 45 1, Otherwise 0	1	126	0.35
		0	114	0.25
Gender	If household is male = 1, Otherwise 0	1	205	0.29
		0	35	0.34
Educ	education of household is literacy =1, Otherwise 0	1	135	0.34
		0	105	0.25
Labs	If labor size is > 2.7 = 1, Otherwise is 0	1	118	0.25
		0	122	0.35
Environmental				
Drought	experience drought yes=1, Otherwise 0	1	145	0.23
		0	95	0.40
ExTemp	extreme temperature yes=1,Otherwise 0	1	54	0.31
		0	186	0.30
Achange	Awareness of weather variation yes=1,	1	126	0.30
	or Otherwise 0	0	114	0.29
Extension and Technological information Services				
Metinf	Access to weather information	1	32	
	Yes=1, Otherwise 0	0	302	
Govinf	Government as information	1	23	
	source =1, Otherwise 0	0	217	
Finsv	Access to financial services	1	110	
	Yes=1, Otherwise 0	0	130	
Seedq	Seed quantity >3 kg/ha, or Seed quantity =< 3 kg	>3	165	
		<=3	175	
InforExt	Accessibility to extension and technological updates =1,	1	159	
	Otherwise 0	0	81	
ylag1	previous rice output kg ha^{-1}	>3431	82	
		<=3431	158	0.25

technology. However, the adoption decision is influenced by variables such as household head's socio-economic, demographic, institutional, and ecological characteristics. The model parameter estimations are built based on equation 1 as described in (*Gujarati 2009*).

$$Q_i = E\left(Y = \frac{1}{X_i}\right) = \beta_0 + \beta_1 X_i \quad (1)$$

When more than one independent variables are used to explain the model, it can be expressed as shown in equation (2).

$$Q_i = E\left(Y = \frac{1}{X_i}\right) = \beta_0 + \sum_{i=1}^{n} \beta_i X_{ki} \quad (2)$$

Where Qi is the probability for a household *i* decided to adopt irrigation technology, β_0 is an intercept of the logistic regression, $\beta_1 \ldots \beta_i$ are set of parameters to be estimated, $X_i \ldots\ldots\ldots X_{ki}$ is the vector variables which influence the household *i* decision for adoption or not to adopt the technology.

$$Q_i = \ln\left(\frac{p_i}{1-p_i}\right) = \beta_0 + \sum_{i=1}^{n} \beta_i X_{ki} + \mu_i \quad (3)$$

In equation 3, P_i is the probability of the household's head (farmer) *i* to adopt the irrigation technology and the ($1-P_i$) is the probability of the same farmer *i* did not decide to adopt the irrigation technology. Therefore, this study could generate a logistic Model with an assumption that Z_i is an interpretable variable to be determined by the logistic equation Q_i.

$$Q_i = f(Z_i) = f\left(\beta_0 + \sum_{i=1}^{n} \beta_i X_{ki} + \mu_i\right) = \frac{1}{(1+Z_i)} \quad (4)$$

By considering the above (equations 1-4), this study could come up with two important assumptions regarding the research objective as follows; If the household's head decide to adopt irrigation technology (equation 5):

$$Q_i = \ln\left(\frac{1}{0}\right) \quad (5)$$

If the household's head decide not to adopt irrigation

Table 2. Descriptive statistics and definition of variables.

Variables	Variable description	Group	Observation	Mean
Age	If household head age < 45 the is 1, Otherwise 0	1	126	0.35
		0	114	0.25
Gender	If household is male = 1, Otherwise 0	1	205	0.29
		0	35	0.34
Edu	education of house hold literacy =1,Otherwise 0	1	135	0.34
		0	105	0.25
Laborsize	If laborsize is > 2.7 = 1, Otherwise is 0	1	118	0.25
		0	122	0.35
Marit	If household is married = 1, Otherwise 0	1	230	1501.26
		0	10	560
Offinc	household ern off-farm income = 1, Otherwise 0	1	102	1596.08
		0	132	1374.64
Environmental				
Drough	experience drought yes=1, Otherwise 0	1		0.23
		0		0.40
Atchan	Awareness of weather variation yes=1,	1		0.30
	or Otherwise 0	0		0.29
Extension and Technological information Services				
AccFin	Access to financial services	1		0.39
	Yes=1, Otherwise 0	0		0.19
Ext	Accessibility to extension and technological updates =1,	1		0.35
	Otherwise 0	0		0.20
Metinf	Accessibility to weather information yes=1, Other-	1		1365.63
	wise=0	0		1484.62
Irrtech	If farmer decided for irrigation yes=1, Otherwise=0	1		1827.78
		0		1314.88

(equation 6):

$$Q_i = ln\left(\frac{1}{0}\right) \quad \textbf{(6)}$$

Operationalization of the Logistic Model for the Irrigation Technology Adoption

The model developed was then processed with the selected variables (**Table 1**). The variables are selected from the data collected during the survey based on the farmers' characteristics including; Socio-economic characteristics, institutional factors, and weather variability.

Empirical Model for Estimating Irrigation Decision Impact on the Rice Yield

This study's intention was to realize the significance of using irrigation technology as a means of rice farmers' reaction to weather variability. Thus, the relationship between the rice yield and farmers' decision to adopt irrigation service was established by using the simple Ordinary Least Square regression. Additionally, this study desired to find out the utility achieved by rice farmers following their decision to use the available irrigation services in the local areas and how could be transmitted to their rice yields in return. The use of the OLS model to express a linear relationship between the dependent and independent variables has been widely explained by *Gujarati* (*2009*) who suggests the use of independents dummy variables. Based on *Gujarati* (*2009*) conclusion, this study used the farmers rice yield (kg ha^{-1}) as a continuous dependent variable and irrigation adoption decision as a dummy variable, other variables such as socio-economic, weather, and institution variables were used as an explanatory variable (equation 7):

$$Y_i = \beta_0 + \beta_1 d_{1i} + \beta_2 d_{2i} + \beta_3 d_{3i} + \cdots + \beta_k d_{ki} + \beta_{k+1} D_i + \mu_i \quad (7)$$

Where, Y_i is the farmers' rice yield in kg ha^{-1}, β_0 is the intercept of the regression equation $\beta_1 ... \beta_{k+1}$ are the respective coefficients of the explanatory variables used in the model, *dki* denote a set of independent variables including the socio-economic and demographic characteristics, weather variables, and institutional variables, D_i indicates the dummy variable, the households head's decision to opt irrigation technology. The dummy variable takes the value of 1 or 0 indicating the presence (example decided) and absence (for not decided) for the referred attribute. The μ_i is an error term of the model which is assumed to be normally distributed with a mean of 0 and constant variance (σ^2). Therefore, substituting the respective variables in equation 7 the study could obtain equation 8 which used the variables defined in (**Table 2**).

RESULTS AND DISCUSSION

Irrigation and Irrigation Methods

Under the prevailing conditions of climate change and weather variability threats, small scale farmers react in different ways such as adopting irrigation, fertilizer and pesticide, and use of drought-resistant seeds so as to increase their resilience to the variations. Generally, irrigation is adopted by smallholder farmers in several areas of the Mbeya Region as a means of subsidizing the rain-fed farming system when there is insufficient water to meet crops' moisture requirements. Similarly, it was identified that small scale farmers in Southern Africa react to water shortage by irrigating their fields (*Mango et al. 2018*). However, going for irrigations depended on various factors, such as geographical locations, water source, financial status, and type of crops. There are several methods that rice farmers use to draw water from sources to the fields. The major methods are by flooding or gravity and by using buckets or watering can. Other methods practiced by a few households are the use of sprinkler and water hoses. Generally, the majority of rice farmers use the gravity method which previously accounted for 75% of the total households. However, the use of sprinklers and water hoses are normally adopted by those located in the urban areas of the Mbeya District.

Socio-economic Characteristics of the Rice Farmers

The distribution of the rice farmers' socio-characteristics indicates that most (56%) rice farmers were between below or equal 45 years with mean age 36.5. Almost all (95.8 %) respondents were married (**Table 3**). The figure is very significant in terms of increasing family labor to take part in rice production. This agrees with (*Otekhile and Verter 2017*) who noted that the majority (61.3 %) of the farmers in Lagos state were married and provide assistance in many agricultural activities.

Education have shown that it is important to farmers since it can help them to have access to credits to support agricultural activities. In this study, it was noted that only 3 % of the farmers had not acquired any formal education.

Table 3. Demographic statistics of the respondents (n=240).

Variable name	Characteristics	Frequency	%	Mean
Age	Below or equal 45years	134	56	36.5
	Above 45	106	44	56.5
Sex	Male	186	77.5	119.0
	Female	54	22.5	121.0
Marital Status	single	10	4.2	106
	Married	230	95.8	121
Education	Illiterate	6	2.5	143
	literate	41	17.1	111
	Primary	169	70.4	120
	Secondary	22	9.2	134
	University	2	0.8	132
Family size	less than 2	22	9.2	1
	2-4	200	83.3	2.7
	5-7	18	7.5	5.4
	Above 7	0	0.0	0
Farm size	1-3	194	80.8	1.75
	4-6	40	16.7	4.65
	Above 6	6	2.5	8.12
Off-farm income	Income < .425	138	58	1374
	Income >=.425	102	42	1596
	Total	240	100	

This confirms that in the study region, most farmers have some literacy, which would help them overcome any related problem that could impede rice production. The majority (83 %) of households have from 2 to 4 members (**Table 3**). Provided that the majority of families in the rural area utilize family labor in farming activities, this number appears to be inadequate. Therefore, a reasonable number of family size is required as proposed in other studies that rural families with up to 7 individuals could be sufficient for major farm operations. On the aspect of farm size, it is shown that the majority of farmers have 0.4-1.3 ha. This is very true to most of the rural farmers in Africa who are characterized by subsistence farming with poor implements. However, studies report small farm size as one of the constrain when farmers want to diversify farm activities (*Kuivanen et al. 2016*).

Most (73 %) household heads have off-farm activities apart from rice farming. This off-farm income could be used to support families and also support rice farming especially on hiring labor, purchasing improved seed varieties, pesticides, and or machinery. Scholars said that off-farm income could help to cut-off production associated risks (*Akhtar et al. 2019*). On the contrary to the findings, the study of (*Baoling et al. 2019*) reported that off-farm income could lead farmers to reduce their yields due to time competition, and leasing out their lands.

Characteristics of Adopters and non- Adopter of Irrigation

Among the rice farmers, only a few farmers (30%) adopted the irrigation technology. This implies that most farmers were reluctant to make the decision to use irrigation as a means of practicing sustainable agriculture. In terms of the reaped mean rice yield, the adopter group acquired a higher average yield of 1827.8 kg ha^{-1} as compared to 1314.9 kg ha^{-1} acquired by non-irrigation adopters. This situation results in existence for major populations with unsustainable income due to the prevailing poor rainfall distribution which cannot support rice production. The use of irrigation technology has improved the living standards and people's well-being through an increased crop yield, income, and opportunity to grow various crops including vegetables to subsidize income from the major crops (*Moyo 2016*). Through focus discussion, the study found out that the main reasons were lack of education and extension service (*Ndhleve 2017*).

Factors for Irrigation Technology Adoption

The factors influencing farmers' decision to adopt irrigation technology which include the education of the households' head, labor size, access to meteorological information, farmers' experiences on droughts events, accessibility to financial credits, previous farm outputs, and access to technological information, were the essential driving force for farmers as they were impacted significantly and positively on their decision making towards irrigation technology adoption (**Table 4**). The Knowledge of these factors could be a good starting point for policy-makers to intervene so as to encourage more farmers to use irrigation technology.

The education level of the household's head. The household heads' education was significant at P>0.001 probability level (**Table 5**). This implies that as the education level of the household heads increase by one level of schooling significantly influenced positively the farmer's decision to adopt irrigation technology.

Thus, as education level increase one times it increases farmers' decision to opt for irrigation technology by 3.5 times when other factors are fixed. This is similar to what (*Ndhleve 2017*) reported that in South Africa, as the year of schooling increases, farmers acquire different knowledge which could help in their agricultural activites such as accessing credits, and adoption of new technologies. The labor size was significant at 0.05 level of probability (**Table 4**). This means that the labor size has a positive influence on rice farmers' decisions for adopting irrigation technology. That is, the increase of family labor size one time, it also increases the farmer's decision to adopt irrigation by 0.39 times. The possible reason could be what was observed by (*Lopez-ridaura et al. 2018*) that an increase in labor size is important to enabling different farm operations which require more labor to perform activities, such as weeding, and fertilizer and pesticides application. Similarly, irrigation operations require additional labors to take-over activities, such as supervising water delivery into the field, and also the construction of furrows which is labor-intensive. Meteorological information was found to also positively influence the farmers' decision. It was very significant at 10 % level of probability. Thus, as farmers' access to meteorological information increase by one time, it increases their decision to adapt to weather variability by 2.7 times provided other factors in the logistic model are fixed. The probable explanation is the access to weather information provide early warning regarding changes in weather conditions. A similar argument was presented in the work of (*Kumar and Khan 2018*) that if agro-meteorological information could be available, more than 75% of farmers would be worth while for crop production in India.

Table 4. Logistic regression results for farmers' decisions for irrigation adoption, Mbeya Region, Tanzania.

Decision to Irrigate	Variables Definition	Odds Ratio	Std. Err.	z	P>z
Age	Age of household head	0.9785	0.0161	-1.3200	0.1870
Gender	Gender of household head	0.7903	0.4078	-0.4600	0.6480
Educ	Education of the household head	3.4779	1.5022	2.8900	0.004***
labs	labor size in the household	0.3903	0.1610	-2.2800	0.023**
Metinf	Meteorological information	2.6280	1.3339	1.9000	0.057*
Drough	Experience drought	0.7655	0.0692	-2.9600	0.003***
Govinf	Government source of Information	0.5193	0.3746	-0.9100	0.3640
Finsv	Accessibility to credits	2.6251	1.0407	2.4300	0.015**
ExpeTem	Experience high Temperature	0.8316	0.3600	-0.4300	0.6700
Ylag1	previous farm outputs	1.0001	0.0001	2.5900	0.0100**
Achange	Awareness to weather changes	0.7788	0.3102	-0.6300	0.5300
Seedq	Amount of seeds used	0.7505	0.2480	-0.8700	0.3850
InforExt	Extension and Technological information	2.6863	1.1494	2.3100	0.021**
_cons	Constant of the model	0.8992	1.3900	-0.0700	0.9450
N of Obsn= 192	LR $ch^2(14)$=55.79	Prob>chi^2=0.0000		Pseudo R^2=0.2338	

Note: the asterisk value represents significant results *** at 1%, ** at 5%, and * at 10% level of significance

Drought was very significant at P>0.001 level of probability. This means holding other factors constant, when the frequency of drought occurrence increase by one unit, the odds of farmers' decision to adopt irrigation technology increases by 0.77 (**Table 4**). This implies that as farmers experience frequent dry spells conditions, it will increase their decisions to go for irrigation services. The finding is supported by the study of (*Webber et al. 2018*) who noted that understanding the effect of Climate change especially drought cases could help farmers to plan for adaptation measures including irrigation technology. The accessibility to financial services was found to have a positive influence on rice farmers' decision to adopt irrigation (**Table 4**). The empirical results indicate that an increase of one unit accessibility to financial aid, the farmer's decision to venture on irrigation will increase by 2.6 times. This was significant at P>0.05 probability level. (*Loboguerrero et al. 2019*) point out that financial supports to farmers increase production, efficiency, and food availability. This is true because accessibility to finance by farmers could accelerate the adoption of technology, increase the ability to pay a water bills, purchase other farm inputs including hiring of labors which in turn increase production. Previous rice output was another important variable to influence the decision of farmers to adopt irrigation technology. The previous farm outputs were significant at 5% level of probability (**Table 4**). Thus, a 1 kg output increase one time, a farmer's decision to use irrigation technology also increased one time, assuming other independent factors are constant. It was very obvious that the increase in farm productivity increases individual confidence to invest more resources in agriculture. Thus, as farmers' outputs increases, it facilitates their decision to adopt modern technology irrigation inclusive so as to earn more income. A similar comment was disclosed in the study of (*Loboguerrero et al. 2019*) who argued that continuing farm investment could depend on the outputs received by farmers; however, they claimed that due to a decline in farm outputs the off-farm income could also be used for such investment.

Extension and technological information was significant at P>0.05 level of probability (**Table 4**). This insists on the essentiality of information dissemination to the farmers. This means a one unit increase on access to extension and technology services, could increase farmer's decision to use irrigation technology by 2.7 times when other factors are fixed. Studies indicate that the availability of extension services is the key point towards the climate change adaptation network (*Mohamad et al. 2017*). Therefore, if farmers are informed of the event of less rainfall and extended dry spells and are giventhe right information regarding extension services and availability of effective technology would increase their decision to adopt the best adaptation mechanisms.

On the other hand, other selected variables that were thought to be among the factors influencing farmers' decisions for adopting irrigation were insignificant (**Table 4**). However, the factor age goes in line with experiences. It was argued that farming experience can influence the adoption of new technology easily. Similarly the farmers with ages between 41 and 50 could easily adopt technology as compared to ages above 70 years (*FAO 2015*). Also, factors such as awareness of weather, and an increase in sunlight duration could also play part in influencing farmers to adopt new technology such as

Table 5. Parameter estimates of Ordinary Least Square Regression for adoption of irrigation technology, Mbeya Region, Tanzania.

Yd (kg ha^{-1})	Definition of Variable	Coef.	Std. Err.	t	P>t
IrrAdop	Irrigation Adoption	316.231	121.6631	2.6	0.010**
ExtTech	Extension and technology information	243.91	116.7812	2.09	0.040**
Accfin	Access to Financial services	297.607	110.6212	2.69	0.010**
Marts	Marital status of the Household head	842.957	272.9272	3.09	0.000***
Offinco	Off-farm income	0.002	0.0003	6.49	0.000***
_cons		-0.788	289.3059	0.00	1.000

*** at 1% level of significance ** at 5% level of significant

irrigation; however, in this study they were insignificant.

Modeling the Contribution of IrrigationTechnology to Rice Yields

In addition to irrigation, the Ordinary Least Square regression illustrates that other independent variable such as availability and accessibility of extension and technological information, access to financial services, the marital status of the household heads and the income from off-farm jobs were also significant to rice yields as they are shown in the regression model equation 8 (**Table 5**).

The positive impacts of irrigation have been also reported in various studies like (*Nazari et al 2018*) who explored the impact of irrigation in agriculture for Iran farmers. The results show that adopting irrigation helped to improve people's livelihood in the rural areas through increased farm production. The improvement was indicated by higher income, improved rural houses, expansion of farms, and better infrastructure. Similar results were also observed in Brazil whereby irrigation contributed to sustaining rural livelihood (*Antônio et al. 2014*). Additionally, *Moyo* (*2016*) noted that adopting irrigation was of paramount importance toward escaping rural poverty in South Africa. He argues that irrigation technology could increase farmers' livelihood through increased production, income, and diversification of income opportunities. Further, irrigation adoption provides pathway opportunities for adopting modern seeds technology, fertilizers, and pesticides which boost production and income. The comparison between Irrigators and non-irrigators in South Africa revealed that the irrigator earned the mean annual income of R 125 007 and non-irrigators earned R 57 608 ('R'-South African Currency). Another study of (*Peter 2015*) in Swaziland commented that adopting irrigation has shifted farmers from subsistence production to commercial production.

Apart from the irrigation adoption, accessibility to extension and technological services influenced rice yield significantly at 5 % level (**Table 5**). A Study of *Emmanuel et al.* (*2016*) indicates that access to extension and technology services through individuals, or different media, fora, and or training groups increase farm income by 243.91 kg ha^{-1} on average. Similar to (*Linh et al. 2019*), (*Ji et al. 2017*) also commented that access to financial service was found to significantly influence farm income positively. Marital status and off-farm income of the household heads significantly influenced the farmer's income. This finding concurs with (*Chen et al. 2019*) who advocate diversification as it is very risky to focus on one income source from agriculture because of many uncertainties including the effect of climate change and weather variability.

CONCLUSIONS AND RECOMMENDATIONS

The majority of rice farmers in the Mbeya region are yet to adopt irrigation technology, which is an essential coping strategy to increase resilience from the impact of weather variability in order to attain sustainable farm outputs. The findings revealed that only a few farmers (30%) have adopted irrigation technology in the study area. The main factors that influenced the decision for adopting irrigation were the education level of the households' head, labor size, accessibility to meteorological information, experiences of drought events, accessibility to financial services in term of credits, previous farm outputs, and availability of extension and technological information. The findings also indicated that the average rice outputs acquired by irrigation adopters were higher than for the non-adopters. Further, findings revealed that the majority of farmers (73%) have off-farm income, which could be used to support the adoption process provided good policies are available.

Apart from the findings, some limitations were observed which have to be considered. The data used for this study only represent one region of Tanzania, which which could be inadequate to draw a conclusion for the whole of Tanzania. Also, the survey covered only rice farmers in the Mbeya region, thus, the findings could not be taken as a general conclusion for all farmers doing other crop varieties. Therefore, in order to have a robust conclusion, more studies should be carried for similar and other different crops in other regions of Tanzania which will make findings noticeable, applicable and acknowledgeable. Additionally, financial factors influenced the decision for adoption of irrigation by farmers. but adopting irrigation technology goes with purchasing implements, new seed variety, fertilizer, etc., which require farmers to demand external funds. Most financial institutions, however, are business-oriented with high interest rates. Therefore, the policy-makers and the financial institutions are urged to have a special consideration to rice farmers so that they could benefit by adopting irrigation through added production, income, sustainable food security, improved house standards, and employment. Additionally, the government of Tanzania should create a conducive and enabled environments for easy access to education are urged to extension services; and for other stakeholders especially the non-public organizations especially the non-public organizations to participate in revamping the agricultural sectors.

REFERENCES

Akhtar, S., Gu-cheng, L. I., Nazir, A., Razzaq, A., Ullah, R. and Faisal, M. 2019. "Maize Production Under Risk : The Simultaneous Adoption of Off-farm Income Diversification and Agricultural Credit to Manage Risk". *Journal of Integrative Agriculture* 18(2): 460–470.

Antônio, D., Coelho, A. B., and Féres, J. G. 2014. "Acta Scientiarum Effects of Climate Change on Irrigation Adoption in Brazil". *Maringá* 36(1):1–9.

Baoling, Z, Ashok, M.M and Bliang. L. 2020. "Grain Subsidy, Off-farm Labor Supply and Farmland Leasing: Evidence From China". *China Economic Review* 62, 101293

Chen, X., Chen, J., and Huang, C. 2019. "Too Risky to Focus on Agriculture ? An Empirical Study of China's Agricultural Households' Off-FarmEmploymentDecisions". *Sustainability JEL* 11(3):1-18.

Cremades, R., Wang, J., and Morris, J. 2015. "Policies, Economic Incentives and the Adoption of Modern Irrigation Technology in China". *Earth System Dynam* 6 399–410.

Emmanuel, D., Owusu-sekyere, E., Owusu, V., and Jordaan, H. 2016. "Impact of Agricultural Extension Service on Adoption of Chemical Fertilizer : Implications for Rice Productivity and Development in Ghana. NJAS–Wageningen". *Journal of Life Sciences* 79:41–49.

Fan, Y. and Mccann, L. 2017. "Farmers' Adoption of Pressure Irrigation Systems and Scientific Irrigation Scheduling Practices: An Application of Multilevel Models". JEL 1–32.

FAO. 2018. "Climate-Smart Agriculture Guideline. United Republic of Tanzania-Ministry of Agriculture Livestock and Fisheries. Dar es Salaam-Tanzania". 2014, 2013-2014.

Gujarati, D. N. S. 2009. Basic Econometrics. 4th Ed. Mc Graw Hill, New York 1-107 pp.

Hunsaker, D. French, A. Waller, P. Bautista, E. Thorp, K. K. Bronson, Andrade-Sanchez, P. 2015. "Comparison of Traditional and ET-based Irrigation Scheduling of Surface-Irrigated Cotton in the Arid Southwestern USA". *Agricultural Water Management* 159(26):209-224.

Iglesias, A. and Garrote, L. 2015. "Adaptation Strategies for Agricultural Water Management Under Climate Change in Europe". *Agricultural Water Management* 155(2015): 119–122.

Ji, C., Guo, H., Jin, S., and Yang, J. 2017. "Outsourcing Agricultural Production : Evidence from Rice Farmers in Zhejiang Province". *PLoS ONE* 12(1), 16.

Jun. X. I. A., D. Qing-yun, L. U. O. Yong, X. I. E. Zheng-hui, L. I. U. Zhi-yu, and M. O. Xing-guo. 2017. "Climate change and water resources : Case study of Eastern Monsoon Region of China," *Advance Climate Change Research* 8(2): 63–67.

Kontogeorgos, A., Sergaki, P., Migdakos, E., and Semos, A. 2014. "Implementing Logistic Regression Analysis to Identify Incentives for Agricultural Cooperative Unions to Adopt Quality Assurance Systems". *International Conference on Applied Economics*. 52: 9–535.

Kuivanen, K. S., Alvarez, S., Michalscheck, M., Adjei-nsiah, S., and Descheemaeker, K. 2016. "Characterizing the Diversity of Smallholder Farming Systems and their Constraints and Opportunities for Innovation : A CaseStudy from the Northern Region, Ghana". NJAS-Wageningen. *Journal of Life Sciences* 78(2016): 153–166.

Kulyakwave, P. D., Xu. S. and Yu, W. 2019. "Rice Farmers' Perceptions and Indicators for Weather Variability in Tanzania: What are the Obstacles for in Situ Adaptations?" *Journal of Physics* 1176(2019): 1–8.

Kumar, V., and Khan, S. 2018. "Importance of Weather Prediction for Sustainable Agriculture in Bihar". India. *Archives of Agriculture and Environmental Science* 2(2):105–108.

Linh, T. N., Long, H. T., Chi, L. Van, Tam, L. T., and Lebailly, P. 2019. "Access to Rural Credit Markets in Developing Countries, the Case of Vietnam: A Literature Review".

Sustainability (Switzerland) 11(5):1–18.

Loboguerrero, A. M., Campbell, B. M., Cooper, P. J. M., Hansen, J. W., Rosenstock, T., and Wollenberg, E. 2019. "Food and Earth Systems : Priorities for Climate Change Adaptation and Mitigation for Agriculture and Food Systems". *Sustainability* (Switzerland) 11(5):2–26.

Lopez-ridaura, S., Frelat, R., Wijk, M. T. Van, Valbuena, D., Krupnik, T. J., and Jat, M. L. 2018. "Climate Smart Agriculture, Farm Household Typologies and Food Security An ex-ante Assessment from Eastern India". *Agricultural Systems* 159:57–68.

Mango, N., Makate, C., Tamene, L., Mponela, P., and Ndengu, G. 2018. "Climate-Smart Agriculture Practice and its Influence". *Land* 7(2):1–19.

Mohamad, A., 2017. Gracy, N., Jürgen, S and Farhad. Z. "The Role of Social Networks in Agricultural Adaptation to Climate Change: Implications for Sustainable Agriculture in Pakistan". *Climate* 5(4):85.

Moyo, T. 2016. The Contribution of Smallholder Irrigation Farming to Rural Livelihoods and the Determinants of Benefits Distribution : The Case of Limpopo Province of South Africa. Doctor of Philosophy (Agricultural Economics). University of Pretoria, 141 pp.

Nazari, B., Liaghat, A., Reza, M., & Keshavarz, M. 2018. "Irrigation Water Management in Iran : Implications for Water use Efficiency Improvement Irrigation Water Management in Iran" . *Agricultural Water Management* 208: 7–18.

Ndhleve, S. 2017. "Impacts of Supplemental Irrigation as a Climate Change Adaptation Strategy for Maize Production : A Case of the Eastern Cape Province of South Africa. *Water South Africa* 43(2): 222–228,

Ngailo, J. A., Mwakasendo, J. A., Kisandu, D. B., and Tippe, D. E. 2016. Rice Farming in the Southern Highlands of Tanzania: Management Practices, Socio-economicRoles and Production Constraints". *European Journal of Research in Social Sciences* 4(4):1-11.

Ntashangase, N. L., Muroyiwa, B., and Sibanda, M. 2018. "Farmers' Perceptions and Factors Influencing the Adoption of No-Till Conservation Agriculture by Small-Scale Farmers in Zashuke, KwaZulu-Natal Province". *Sustainability* (Switzerland) 10(2):1–16.

Otekhile, C. A., and Verter, N. 2017. "The Socioeconomic Characteristics of Rural Farmers and their Net Income in Ojo and Badagry Local Government Areas of Lagos State, Nigeria. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis* 656, 2037–2043.

Peter, G. 2015. The impact of Small-scale Irrigation Schemes on Household Food Security". *Journal of Sustainable Development in Africa* 13(6): 1–17.

Rapsomanikis, G. 2015. The Economic Lives of Smallholder Farmers: An analysis based on household data from nine countries. Food and Agriculture Organization. Rome. https://www.fao.org/3/i5251e/i5251e.pdf

Swanepoel, G., Hadrich, J.C., and Goemans, C. 2015. "Estimating the Contribution of Groundwater Irrigation to Farmland Values in Phillips County, Colorado. *American Society of Farm Managers and Rural Appraisers* 6(2015): 165-178

Tang, J., Folmer, H., Xue, J. 2016. "Adoption of Farm-Based Irrigation Water-Saving Techniques in the Guanzhong Plain, China". *Agricultural Economics* 47(4): 445–455.

Webber, H., Ewert, F., Olesen, J. E., Müller, C., Fronzek, S., Ruane, A. C. Gaiser, T. 2018. Diverging Importance of Drought Stress for Maize and Winter Wheat in Europe". *Nature Communications* 9(4249):1–10.

Xing-guo, M. O. Shi. H. U., Zhong-hui. L. I. N., Su-xia, L. I. U. and Jun. X. I. 2017. "Impacts of Climate Change on Agricultural Water Resources and Adaptation on the North China Plain". *Adv. Climate Change Research* 8(2): 95–98.

Yu, C. Huang, X. H. Chen,. Huang. G. Ni S, and Wright. J. S. 2018. "Assessing the Impacts of Extreme Agricultural Droughts in China Under Climate and Socioeconomic Changes Earth ' s Future". *Earth's Future* 6: 689–703.

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