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Factors Affecting the Adoption of Micro-Irrigation Technologies at Wenimbi Irrigation Scheme, Zimbabwe

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Abstract: ***Micro-irrigation technologies are vital function in the economic growth, improving food security, poverty reduction and smallholder farmer development. However, because of water scarcity and growing need to save water for agriculture, micro-irrigation technologies are needed for sustainable agriculture and food security. Therefore, this study's main purpose was to identify and establish factors that are affecting the adoption of micro-irrigation technologies at Wenimbi Irrigation Scheme. The study used a combination of qualitative and quantitative methods. A sample of 65 farmers was randomly selected from the irrigation scheme. Data was analysed using descriptive statistics and linear multiple regression. The study revealed that 72% of farmers use micro-irrigation technologies (drip and sprinkler) and 28% of the farmers use non micro-irrigation technologies (flood and hosepipe). The results of the stepwise linear multiple regressions showed that education in years, non-farm income, organizational mean score and area planted were y significantly predicting total income of micro-irrigation technology. The study recommends the interaction among various stakeholders such as government, non-government organizations, private sector, researchers, extension workers and farmers to ensure sustainability of micro-irrigation technologies.***

Keywords: Micro-irrigation technologies, adoption, subsidies, policy

1. Introduction

Water is an essential natural resource for the survival of life and a key input for plant growth. Climate change and variability is a contributing factor to the persistent droughts and dry spells, which have resulted into noticeable increase in the support and use of micro-irrigation technologies. Sprinkler and drip irrigation methods are adopted as key input for successful crop production and are selected according to soil types, topography, water supply, type of crop and other management practices [1]. Adoption of improved micro-irrigation technologies are associated with reduction of poverty, improved nutritional status, lower staple food prices, increased employment opportunities as well as earnings for landless labourers [2].

More than 80% of accessible water resources worldwide are being currently utilized for irrigation purposes and development. These technologies are mainly related to smallholder farmers in developing countries Zimbabwe included, which makes them a priority for developmental efforts. However, the adoption of modern micro-irrigation technologies facilitates the efficient use of available irrigation water [3]. This ultimately helps farmers to expand planting area under irrigation thereby increasing agriculture production and productivity as well as horticulture per hectare per unit of water used. In recent years, the danger of droughts has been on an increase because of climate change [4] and water pollution [5], which has further raised potential vulnerability of agricultural production and productivity. Use of water management technologies helps in strengthening the national economy and employment [6]. During the past decades, much research has been done at the field level and various technologies in micro-irrigation have been proposed [7]. Some researchers have proved sufficiently that where there is available irrigation water for agriculture, well managed and used in a good scientific way will save and increase agriculture production and productivity [8].

In answering to the water crisis, the Zimbabwean government in recent years begun providing investigations into micro-irrigation technologies in the agricultural sector, although there is debate about the extent of achievement in adoption by farmers [9]. India has shown a considerable farmers' investment in micro-irrigation technologies [10] and [11]. There are substantial efforts made to disseminate the technologies through mass media, demonstrations, research and extension services though there are factors affecting the rate of adopters and non-adopters, which is the focus of this paper.

2. Problem Definition

Agriculture is an important industry in Zimbabwe where about 70% of the population depends on it. However, because of climate change and variability it is necessary to adopt micro-irrigation technologies, which save water and as a mitigating factor against droughts. Hence, micro-irrigation technologies provide opportunity to increase production and productivity throughout the year, which becomes a major necessity for farmers as they improve efficiency while saving water resources. Research and extension service in agricultural technologies are vital factors in the economic growth of any developing countries like Zimbabwe.

With the increase in population, Zimbabwe has placed a heavy weight on crop production and needs new necessities for micro-irrigation technologies through research and extension to publicize information. The adoption of sprinklers and drip irrigation are more recent than the flood and hosepipe technologies as revealed by [12]. Literature show that government support is an important factor in farmers' decisions whether to adopt the modern micro- irrigation technologies. Therefore, studies on the impacts and adoption of micro-irrigation on farming system as a whole are scanty and still need to be explored much as the adoption is lower than anticipated by the government [9]. This study investigated factors affecting the adoption levels of micro-irrigation technologies by smallholder farmers at Wenimbi Irrigation Scheme in Marondera District, Mashonaland East Province, Zimbabwe.

3. Literature Review

3.1 Wenimbi Irrigation Scheme Management

The scheme started in 1990 with full farmer participation by providing labour and funding. Ministry of Agriculture, Mechanization and Irrigation Development provides technical and extension services, with cropping guidance and crop rotations. Farmers receive medium term loans payable over ten years from banks and other agricultural financial support groups and seeds from seed houses on credits. The government at times provides free inputs for subsidizing the smallholder farmer`s production costs. A significant positive relationship between subsidies and adoption levels of micro-irrigation technologies have been found by [9].

In technical constraints, knowledge and technical advice from extension activities are very effective ways to increase the level of adoption [14], [12]. Operation, maintenance and management are run by a committee with the assistance from Ministry of Agriculture, Mechanization and Irrigation Development departments which oversee the overall coordination of the infrastructure maintenance and payment of bills, though individual farmers are responsible for any breakdown repairs within their plots. Initially, farmers` grew various crops, which had no profits but later focused on strategic crops that have high returns. Tomatoes, leaf vegetables and grain maize became the major crops at the irrigation scheme with high profits.

3.2 Micro-irrigation adoption

Adoption is the integration of a new technology into existing practice and is preceded by a period of trying and degree of adoption [15]. However, it is measured in two categories, which are the rate of adoption and its intensity level. The relative speeds which farmers adopt an innovation depend on time while intensity of adoption is the level use of a given technology in any period [16].

The variation of micro-irrigation technologies can be seen by the crop area planted by the smallholder farmers. Although, the system is appropriate for all kind of lands but its embracing varied from region to region because of geographical distinctiveness and sources of water [9]. On the farmer side, financial assets, accessibility of labour, training, transportation and dissemination also add to technology adoption [16]. However, many countries have categorized farmers in different groups according to their land holding capacity and those who adopted drip and sprinkler irrigation systems in Gujarat India are rich to very rich farmers [11]. The adoption of micro-irrigation technologies in farmland affects the cropping patterns of several crops and fruits. According to [12] stated that farmer who adopts alternative micro-irrigation technologies has changed their crops and has emboldened farmers to enhance their overall cropping strength to shift their cropping patterns to high-value and water intensive crops [17]. However, the position of Wenimbi irrigation scheme in Zimbabwe revealed that yield improvements from micro-irrigation technologies are reliant on the crops grown, soil type and type of irrigation technology used [18].

4. Objectives of the Study

Major objective is to identify and establish factors that are affecting the adoption levels of micro-irrigation technologies. The specific objectives of the study were:

a) To identify characteristics of farmers;
b) To identify the existing irrigation systems;
c) To find out the extent of micro-irrigation adoption levels;
d) To find out factors affecting micro-irrigation technologies adoption; and,
e) To know policy actions being taken for speeding up the adoption of micro-irrigation systems.

5. Methodology

The study was conducted at Wenimbi Irrigation Scheme in Marondera District, Mashonaland East Province, Zimbabwe (Figure 1). A combination of qualitative and quantitative data analysis approaches was employed. A semi-structured farmer questionnaire was used for quantitative data collection and was pre-tested randomly for feedback to improve the survey questionnaires and checklists questions. Sample size of 65 smallholder farmers were randomly selected for interview and key informants from scheme management committee members, private sector and officials from Ministry of Agriculture, Mechanization and Irrigation Development who provide services to the scheme. Focus group discussions and field observations were contacted to evaluate the repair and maintenance position of the irrigation scheme infrastructure. Literature review approach was employed to understand past and current key policy regulatory and institutional arrangements that guided the utilization and management of micro-irrigation infrastructure development. Data was analyzed using descriptive statistics and stepwise linear multiple regressions.

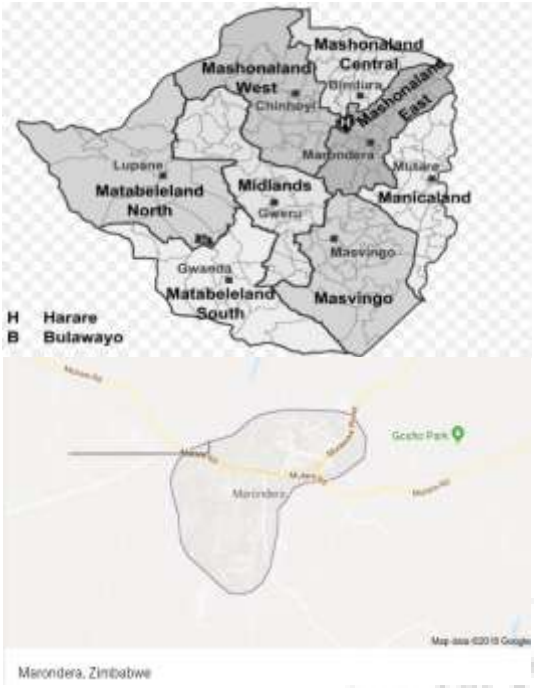

Figure 1: Wenimbi irrigation scheme

6. Model Specification

Stepwise Linear Multiple Regression

Linear multiple regression was applied to determine the factors affecting total income of micro-irrigation technologies. According to [19] linear multiple regression is used to model relationships between a continuous outcome variable and a set of regressor variables, which might be either all continuous variables or both continuous and dummy categorical variables. The study model expressed as:

$$Y = \beta_0 + \beta_1 X_1 + ... + \beta_k X_k + \varepsilon_i \quad (1)$$

Where:

Y = Dependent variable
β_0 = Y intercept
β_k = Regression coefficient, ($k = 0, 1 ... n$)
n = total number of independent variables
X_k = k_{th} independent variable
ε_i = error term

The variables used in the regression model were:

Y = Total income of MI technologies ($)
X_1 = Non-farm income ($)
X_2 = Area planted (hectares)
X_3 = Organisation mean score
X_4 = Education level (years)
ε_i = Error term

7. Results and Discussion

7.1 Socio-economic characteristics of farmers

Frequency and percentages were used to determine the socio-economic characteristics of smallholder farmers. It was found that majority (56.9%) of sampled farmers was male and majorities (53.8%) of farmers were in the age group of 31 to 45 years. Table 1 show that majorities (58.5%) of farmers were married and 55.4% had secondary school education level. Study revealed that 61.5% of farmers had not received agricultural training and majority (53.8%) of farmers had 21 to 30 years farming experience.

Table 1: Socio-Economic Characteristics of Farmers

Variable	Category	Frequency	Percent (%)
Farmer's sex	Female	28	43.1
	Male	37	56.9
Farmer's age	15 – 30 years	20	30.8
	31 - 45years	35	53.8
	46 – 60 years	9	13.8
	Above 60 years	1	1.5
Marital status	Married	38	58.5
	Single	13	20
	Widowed	9	13.8
	Divorced	5	7.7
Educational level	Primary	3	4.6
	Secondary	36	55.4
	Advanced level	15	23.1
	University	11	16.9
Agricultural training received	Yes	25	38.5
	No	40	61.5
Farming experience	10 years	1	1.5
	11 - 20 years	10	15.4
	21 - 30 years	35	53.8
	31 - 40 years	16	24.6
	Above 41 years	3	4.6

7.2 Existing Irrigation Systems

Figure 2 shows that drip (48%) and sprinkler (25%) irrigation types are the most used, showing a shifting from old systems to modern MI technologies, which save water and labour, increase income and reduce poverty hence food and nutrition security maintained. The results show most farm households taking drip as the major irrigation system [10] as shown on Figure 2.

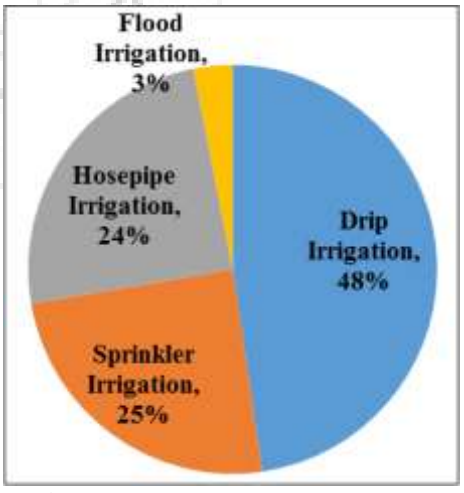

Figure 2: Existing Irrigation Systems

7.2.1 Extent of micro-irrigation adoption

The study indicates 72% of smallholder farmers at Wenimbi irrigation scheme have adopted the use of modern micro-irrigation technologies (drip and sprinkler) while 28% were non-adopters as shown in Figure 3. This study is consistence with findings of [23] who found out that extent

and intensity of adoption of MI is limited when subsidies and extension activities are not promoted.

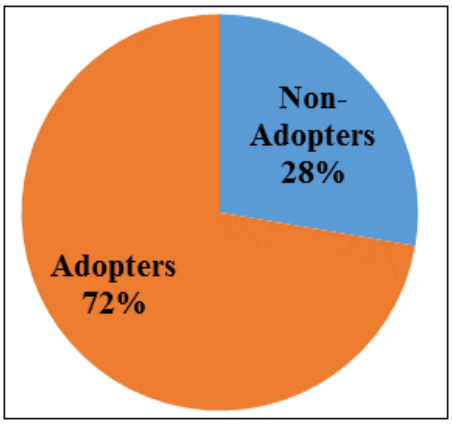

Figure 3: Extent of Micro-Irrigation Adoption

7.2.2 Farmer participation in organizations

Table 2 shows that farmers participate in various organizations, which are vital in sourcing and quick spreading of information to members and developmental projects. Farmer participation in organizations was rated on a four point Likert type scale based on their use or not use of MI technologies. Under development organizations, 43% of farmers showed an inactive role while 46% of farmers had an active role in farmer organization. This means farmers are actively engaged in farmer organization activities involving input and labour exchange, which makes them available to those in deficits [21]; [22]. Religious farmer organization had 34% of farmers being non-member to religious organizations, which shows that some farmers spend much time in the fields. However, 34% of farmers were not members of professional organizations but 40% of farmers were active in cooperative organizations. Smallholder farmer participation in different organizations is essential in networking within a community.

Table 2: Farmer Participation in Organizations

Type of Organisation	Category	Frequency		Percent (%)	
		Not using MI	Using MI	Not using MI	Using MI
Development organization	Non member	5	10	8%	15%
	In active	11	28	17%	43%
	Active	2	9	3%	14%
	Very active	0	0	0%	0%
	Non member	0	0	0%	0%
Farmer organization	In active	2	4	3%	6%
	Active	6	30	9%	46%
	Very active	10	13	15%	20%
	Non member	0	2	0%	3%
Religious organization	In active	3	8	5%	12%
	Active	8	24	12%	37%
	Very active	7	13	11%	20%
	No member	9	22	14%	34%
Professional organization	In active	6	14	9%	22%
	Active	3	11	5%	17%
	Very active	0	0	0%	0%
	Non member	0	0	0%	0%
Cooperative organization	In active	5	15	8%	23%
	Active	11	26	17%	40%
	Very active	2	6	3%	9%

Farmer participation in organizations was rated as 1 = Non-member, 2 = Inactive, 3 = Active and 4 =Very active

7.3 Factors affecting micro-irrigation technologies adoption

The purpose of the study was to analyze the influence of different independent variables on total income (dependent variable), which affects MI technology adoption by farmers. To accomplish this, a stepwise multiple linear regression model was used to regress 13 independent variables in the model.

7.3.1 Descriptive statistics of dependent and independent variables

Table 3 shows the mean and standard deviation of variables regressed in the multiple linear regression model for the adoption of micro-irrigation technologies. The mean area planted was 4.16 hectares (*SD* = 1.35 ha). The mean education level in years was 3.68 years (*SD* = 1.12 years) and non-farm income had a mean of $242.15 (*SD* = $422.18). The organization mean score was 1.57 (*SD* = 0.33). While the mean total income was $1594.11 (SD = $575.55).

Table 3: Descriptive Statistics of Significant Independent Variables

Variable	N	Mean	Std. Deviation
Total Income ($)	65	$1594.11	$575.55
Area planted (Ha)	65	4.16	1.35
Education level (Years)	65	3.68	1.12
Nonfarm income ($)	65	$242.15	$422.18
Organization mean score	65	1.57	0.33

7.3.2 Pearson correlation of dependent and independent variables

Table 4 indicates that there was a significant positive correlation between total income and area planted, r = 0.239, p < 0.05. In addition, total income and education level in years were significantly positively correlated, r =0.216, p < 0.05. Total income was significantly positively correlated with non-farm income, r =0.364, p < 0.01. Organizational mean scores were significantly positively correlated with total income, r =0.333, p < 0.01. In addition area planted and non-farm income were significantly positively correlated, r =0.298, p < 0.01.

Table 4: Pearson Correlation of Dependent and Independent Variables

Variable	Total income	Area planted	Education in years	Non-farm income	Organisation mean score
Total income	1	0.239*	0.216*	0.364**	0.333**
Area planted		1	0.094	0.298**	0.146
Education in years			1	0.067	0.047
Non-farm income				1	0.093
Organisation mean score					1

*Significant at 5% & ** Significant at 1% levels of significance

7.3.3 Stepwise Multiple Linear Regression

(a) Model summary of stepwise regression model

Table 5 shows the model summary that provides the R, R^2, adjusted R^2, changes in statistics and Durban-Watson value. This study reveals gradual increase in variance showed by R^2 from 13.3%, 26.5%, 32.2% to 37.3% for model 1, 2, 3 and 4 respectively, meaning that each variable added is improving the variance due to independent variables on the outcome variable. Therefore, the regression model indicates 37.3% of the total variance in the dependent variable (total income) is explained by the linear combination of education in years, area planted, organizational mean score and non-farm income. The Durbin-Watson value is approximately equal to 2 (DW = 1.893), which indicates the absence of autocorrelation in the estimated model. This means between the variables entered into the equation there is no autocorrelation and therefore they have independent influence on the total income.

Table 5: Model Summary of Stepwise Regression Model

				Change statistics			
Model	Multiple R	R^2	Adjusted R^2	R square Change	F Change	Sig F Change	Durban Watson
Step 1	0.364	0.133	0.119	0.133	9.642	0.003	
Step 2	0.515	0.265	0.241	0.132	11.158	0.001	
Step 3	0.567	0.322	0.288	0.057	5.096	0.028	1.893
Step 4	0.611	0.373	0.332	0.052	4.95	0.030	

(b) Stepwise multiple regression model for predicting variables

The F-statistics show that the model passed the test of overall significance at 1% level (Table 6). This means that all the independent variables combined had a significant influence on total income. The coefficients of the independent variables are positive and significant implying that the farmer`s total income increases. Among these independent variables analyzed only four namely area planted, education in years, non-farm income and organizational mean score were significantly influencing the dependent variable, which is total income. This demonstrates that area planted, education in years, non-farm income and organizational mean score had significant impact on smallholder farmer`s total income. While farm size, total labour, irrigation farming experience, mass media, gender, number of dependents, assets mean score, irrigation experience, total production and farmer relation means score were not significantly influencing total income.

The study revealed that area planted had positively and significantly influenced total income of irrigation farmers [24]. An increase in area planted is likely to lead to more high-value crops grown. The study revealed that education level significantly influenced total income of irrigation farmers. A study by [25] and [26] on adoption of organic fertilizers found that the level of education had a positive and significant influence on adoption levels of a technology. This is because higher education level influences farmers' attitudes and thoughts, which make them more open, rational and able to analyze the benefits of a new technology [18]. The study also revealed that non farm income positively and significantly influenced total income of irrigation farmers. The non-farm income makes farmers diverse and increase crop varieties on the farm [26]. The results show that organization mean score significantly influenced total income of irrigation farmers. According to [27] farmers who belong to social groups mostly enhance social capital trust ideas and information exchange. Usually farmers within a social group copy and learn from each other the benefits and usage of a new technology and its adaptation. Other studies reveal that farmers who participate more in community-based organizations are likely to engage in social learning hence raising their likelihood to adopt the modern technologies.

Table 6: Stepwise Multiple Regression Model for Predicting Total Income of MI Technologies Adoption

Model	Independent Variables	B	SE (B)	t	Tolerance	VIF	F-ratio
1	(Constant)	1473.835	77.397	19.043			9.642**
	Nonfarm Income	0.497	0.160	3.105**	1.000	1.000	
2	(Constant)	762.063	224.857	3.389			11.178**
	Nonfarm Income	0.651	0.155	4.189**	0.911	1.097	
	Area planted	162.162	48.545	3.340**	0.911	1.097	
3	(Constant)	193.628	332.914	0.582			9.643**
	Nonfarm Income	0.602	0.152	3.954**	0.892	1.120	
	Area planted	142.413	47.824	2.978**	0.881	1.135	
	organization mean score	423.050	187.401	2.257*	0.958	1.044	
4	(Constant)	-240.119	376.958	-0.637			8.938**
	Nonfarm Income	0.612	0.148	4.150**	0.892	1.122	
	Area planted	133.463	46.521	2.869**	0.874	1.144	
	organization mean score	445.795	181.900	2.451*	0.955	1.047	
	Education level	117.694	52.898	2.225*	0.986	1.014	

*Significant at 5% & ** Significant at 1% levels of significance

7.4 Government's role in adoption of micro-irrigation technologies

Government guides the agricultural policy and plays an important role in the financial support through subsidies and extension training. Zimbabwe is encouraging water saving techniques like growing crops that use less water uptake and breed new varieties that need less water like small grains and short duration crops. Micro-irrigation technologies such as drip and sprinkler are becoming popular and get support from various government departments, private sector and NGOs as they increase food and nutritional security, water saving techniques and labour.

8. Conclusion

After testing several variables, area planted, non-farm income, organizational means score and educations in years are positively significantly influencing adoption of micro-irrigation technologies. This means that smallholder farmers with high total income have high opportunities to increase the adoption level of micro-irrigation technologies. There is need to spread and expand MI to areas and regions with high potential benefit through extension activities. Data analyses show that government, private sector and NGOs are playing vital roles in promoting MI adoption levels by providing subsidies, loans and technical knowledge.

9. Recommendations

9.1 Recommendation for farmers

Adoption of micro-irrigation technologies has shown an increase in food production and productivity hence improves on livelihoods and food nutritional health security for farmers. Since smallholder farmers play important part during projects development, execution and assessment phases through assistance from extension staff, they should not only rely on agencies to do everything for them but should learn "as seeing is believing". Micro-irrigation adoption is economical in water saving techniques hence has higher benefits to water stressed crops and fruit trees in this climate change and variability periods. To enhance adoption of micro-irrigation technologies, smallholder farmers should seek recent information and advice from extension workers, private partners, researchers and government institutions. Furthermore, smallholder farmers should work together with local farmer organization for networking and sharing new ideas on markets, inputs, labor and equipment. Then take farming as a business through MI technologies hence food security for the expansion population.

9.2 Recommendation for Government

Policy and regulatory issues are to make irrigated agriculture the backbone of national food and nutritional security. The most important aspects that influence adoption of micro-irrigation technologies are efforts by the policy makers that include governments, private sector and NGOs in having long-term service provision on training. Policies should have strong poverty alleviation focus like water rights that encourages the potential to improve incomes, building awareness and outputs for the poor smallholder farmers on micro-irrigation technologies.

10. Recommendations

- The management of irrigated agriculture must be guided by Statutory Instruments, which address specific issues like water rights.
- Governments should have facilitation roles in sourcing lines of credit from banks, NGOs and the private sector for irrigation infrastructure development with farmers responsible for loan repayment, long-term and low-interest loans to poor farmers and the medium-income farmers.
- It is sustainable to build up farmer managed micro-irrigation schemes, as they ease the financial burden on government in terms of operations and management like at Wenimbi irrigation scheme in Zimbabwe.
- Since water is the most restrictive variable factor in smallholder irrigation growth, well-organized micro-irrigation systems must be positive in this sector in order to save water and development of irrigation technologies with low energy requirements.
- Training in water saving supervision, marketing and general crop, fruit production and productivity is vital for new and old micro-irrigation schemes and help farmers with inputs for the first season so as to build a cash flow base.
- Monitoring and evaluation of micro- irrigation schemes is necessary to provide feedback and information, which is important for future planning and coordination of relevant institutions involved in smallholder irrigation development.
- Agricultural research, extension services and training should be strengthened by increasing interaction among various stakeholders (government, farmer, NGOs and private sector) by providing incentives like transport to ensure frequent field visits.

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