ADOPTION OF RAINFED PADDY PRODUCTION TECHNOLOGIES AMONG SMALLHOLDER FARMERS: A CASE OF CENTRAL DISTRICT-ZANZIBAR, TANZANIA

ABSTRACT

This study intended to determine factors affecting the adoption of new technologies in rainfed paddy production practiced by smallholder farmers in the Central District-Zanzibar, Tanzania. A cross-sectional research design was employed. A structured questionnaire, focus group discussions (FGDs) and key informant (KI) interviews were used to explore issues related to rainfed paddy production. 120 respondents who were engaged in rainfed paddy farming were selected from 4 village clusters (30 respondents in each village cluster) from December 2013 to January 2014. Data were analysed using descriptive statistics and binary logistic regression model. Results show that majority of respondents (55%) were female while 45% were male aging 19-59 years. The study revealed that rainfed paddy production technologies that were adopted by smallholder farmers included row planting, fertilizer application (P=.03), weed control and the use of improved paddy seed varieties (p= .04). Descriptive analysis results showed that the adoption level of technologies was high. The logistic regression analysis showed that extension services, age, off-farm income and distance from residence to the marketplaces were factors that influenced the decisions of smallholder farmers to adopt technologies (p<.05). Researchers recommend that the government of Zanzibar should continue providing efficient extension services to smallholder farmers in order to ensure sustainability in the adoption of rainfed paddy production technologies in Zanzibar.

Keywords: (Adoption, rainfed paddy production, technologies, smallholder farmers)

1. INTRODUCTION

Most developing countries depend on agriculture for economic growth, poverty reduction, and food security [1]. In Zanzibar particularly in rural areas, agriculture remains to be an important economic activity to the majority and remains the second largest driver of economic development after the services sector[1]. Nearly 70% of the population depends directly or indirectly on agriculture-related activities for their livelihood. The share of the agriculture sector in the economy decreased from 24.0% in 2006 to 21.7% in 2010 [2]. Although dominated by small-scale subsistence farming, agriculture is by far the most important source of food and employment in the isles.

According to the office of the Chief Government Statistician, Zanzibar [OCGS, 2012] [3], only a small proportion of cropland is irrigated. The Zanzibar Irrigation Master Plan [4] has identified 8 000 ha as suitable for irrigation development in both Unguja and Pemba islands. The master plan states that paddy occupies about 15 000 ha from the total cropland area of 122 600 ha including tree crops. Out of 15 000 ha, the irrigated area covers only 450 ha, and the rest is non-irrigated (7 550 ha rainfed lowland and 7 000 ha upland). Paddy has occupied a prominent position as a strategic crop for food security and economic development. It is the main staple food which accounts for more than 50% of staples consumed in Zanzibar. It is estimated that per capita annual rice consumption is 120 kg, and total annual rice requirement is estimated at 120 000 tons [5].

The attainment of an increase in paddy production is still a big challenge. Towards the turn of the last century, the Revolutionary Government of Zanzibar took deliberate steps to support local paddy production. Some of the efforts include a subsidy for mechanization, quality seeds, fertilizers and herbicides. Despite these efforts and strategies, there are still many households that are experiencing food insecurity due to low paddy production. In general, the paddy production trend has been low due to a variety of constraints including weed infestation, improper soil and water management, plant diseases

[1] Services sector dominated mainly by tourism

and pests, inadequate use of fertilizers, inadequate research and extension services, and limited availability of appropriate improved varieties Khatib, 2009 cited by Kimaro *et al*., [6].

The widespread use and adoption of new agricultural technologies in the form of improved varieties, fertilizers, pesticides, agricultural machinery and method of cultivation like proper spacing could significantly increase food production in developing countries [7]. Also, Essa [8] revealed that the adoption of a new agricultural technology is a central feature of the transformation of farming systems in the process of economic development. Farmers have an essential role to play in agriculture development. They are the ones to decide on the use of agricultural inputs and adoption of improved agricultural technologies. According to Umar *et al.* [9], the adoption of improved technologies can lead to increased productivity to smallholder farmers.

Low levels of skills with respect to the use of modern farming techniques and adoption of new technologies is one of the challenges facing paddy production. According to Khatib and Makame[5], the adoption of improved paddy varieties, proper application of chemical fertilizers and associated agronomic technologies is still low in Zanzibar, particularly in rainfed paddy production. Therefore, this study aimed to ascertain factors that influence adoption of rainfed paddy technologies among smallholder farmers in Zanzibar.

2. MATERIAL AND METHODS

2.1 Description of the Study Area

2.1.1 Location

This study was conducted in the Central District. It is one of the two districts which form Unguja South Region. The district [Fig. 2] has a total area of about 453 km2. It is bordered by South District to the south, West District to the west, North B District to the north and the Indian Ocean to the east.

Figure2: Map of Central District showing the study area

2.1.2 Demographic characteristics

Central District is comprised of three constituencies, 11 wards and 40 Shehia [village clusters]. According to the 2010 census, Central District currently has a population of 76 346 of whom 38,538 are males and 37,808 are females, and average household size is 4.5.

2.1.3 Agro-ecological conditions

The district climate is characterized by the northern monsoon winds between the months of December and February and the southeast monsoon winds between the months of March and November. Central District is dominated by a bimodal rainfall pattern. There is a long rainy season [Masika] which starts from March up to June with an average of 900-1000 mm precipitation during this season, followed by rather erratic short rains [Vuli] which start from October through December with an average of 400-500 mm of rainfall. In the district, the temperature remains relatively stable throughout the year. The maximum mean annual temperature (30oC) and the minimum mean annual temperature approximately 24oC. The geology of Central District is characterized by deeper and richer soils on the western side, but become shallow towards the eastern side dominated by coral rag consisting of weathered rocks with pockets of fertile soils.

2.1.4 Economic activities

The major income sources for the residents include business, office work, carpentry, arable and pastoral farming, fishing, tourism and harvesting of forest products. The main food crops grown in Central District include paddy, cassava, bananas, sweet potatoes, yams, maize, seaweed and cloves. The reason for undertaking this study is that the district has the potential to be the food basket of Unguja given the availability of arable land [1, 200 ha in Cheju valley], good climatic conditions, and availability of water and forest resources.

2.2 Research Design

A cross-sectional research design was adopted in the process of data collection. The design has been adopted on the basis that it allows collection of data from different groups of respondents at one point in time (De vaus 2002 as cited by Ruheza et al.[10]). Furthermore, the design can also be used to determine the relationship between and among variables [11].

2.3 Sampling Procedure and Sampling Size

Purposive sampling was used to select four Shehia [village clusters] namely, Jendele, Cheju, Ndijani Mseweni and Ndijani Mwembepunda. Purposive selection of these Shehia was based on the fact that they are located in Cheju valley, the largest valley in Zanzibar which makes them potential for rainfed paddy production, furthermore multiple rainfed paddy production interventions are allocated to the Cheju valley. A systematic random sampling was used to obtain 120 respondents from the selected Shehia by using farmers' register as a sampling frame, 30 cases were selected from each Shehia. The unit of analysis was the household. According to Kothari[12] and Wooldridge [13], a sample or sub-sample of 30 respondents is the minimum for studies in which statistical data analysis is to be done. The choice of this figure was also based on the simple formula of selecting sample as suggested by Fisher et al.[14] for a population that exceeds 10 000 as shown below:

$$n = \frac{Z^2 pq}{d^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where:

n = desired sample size when population is greater than 10 000

Z = standard normal deviation, set as 1.96 (or simply at 2.0) corresponding to 95% confidence level

p = proportion in the target population estimated to have a particular characteristics

q = 1 – p

d = degree of accuracy desired, set at 0.05

Hence sample size will be

$$n = \frac{Z^2 pq}{d^2} = \frac{(2^2)(0.5 \times 0.5)}{(0.05)^2}$$

n = 400 respondents

According to the formula the sample size for this study could have been 400 cases but due to time limitation and funds, 30% of the cases were selected to be involved in this study. Bailey [15] argued that a sample of 30 respondents is a bare minimum for a study in which a statistical analysis is to be done.

2.4 Data Collection Instruments

2.4.1 Primary data

A structured questionnaire [Appendix 1] was used to collect primary data from smallholder farmers. Other methods used for primary data collection were focus group discussions [FGDs] and key informant [KI] interviews. Four FGDs were conducted involving 10 participants for each Shehia, the selection of FGDs participants was based on their experience and involvement in rainfed paddy production. Additionally, 10 key informants including Block Extension Officers, the District Agricultural Development Officer and Subject Matter Specialists on rice production were also purposively selected based on their knowledge in paddy production. The questionnaire was made up of five main parts. The first and second parts were designed to collect household characteristics. The third part covered farming and socio-economic characteristics, while the fourth part dealt with the extension services and technology adoption. The final part was designed to capture information related to credit and market accessibility. The second instrument was the checklist which comprised both focus group discussion guides and key informant guide [Appendix 2].

2.4.2 Secondary data

Secondary data were obtained from reports found in the Ministry of Agriculture and Natural Resources in Zanzibar, Zanzibar Department of Agriculture and Central District Agriculture Development Offices. Data collected included the type of paddy technologies transmitted to farmers, extension and other services provided to smallholder farmers, type of credit provided to farmers and level of technologies adoption by smallholder farmers.

2.5 Data Analysis

2.5.1 Quantitative data analysis

The descriptive and inferential analysis was used to analyze quantitative data. The collected primary data were verified, coded, and analysed using Statistical Package for Social Science [SPSS] computer program, version 16, which yielded descriptive statistics such as frequencies, percentages, means, range, minimum, maximum and cross-tabulations. Inferential statistics [Binary logistic regression model) were applied to determine factors influencing rainfed paddy technology adoption.

2.5.2 The binary logistic regression model

The decision to adopt or not adopt a particular new production technology is a binary decision that can be analysed using binary choice models [16; 17]. In determining household social economic and farmer characteristics affecting the adoption of rainfed paddy production technology by smallholder farmers in the study area, a logistic model was employed. Logistic regression is useful for situations in which one wants to be able to predict the presence or absence of a characteristic or outcome based on values of a set of predictor variables [1]. It is similar to a linear regression model but is suited to models where the dependent variable is dichotomous. Logistic regression coefficients can be used to estimate odds ratios for each of the independent variables in the model. The estimated model is expressed as follows:

$$Y = \alpha+\beta o + \beta 1x1 + \beta 2x2 + \ldots \beta n\, xn + \varepsilon \qquad (2)$$

$$Y = \alpha + \beta 1 \text{ age} + \beta 2\text{sex} + \beta 3 \text{ education} + \beta 4 \text{ farm size} + \beta 5 \text{ credit access} + \beta 6 \text{ extension services} + \beta 7 \text{ market accessibility} + \beta 8 \text{ household size} + \beta 9 \text{ farming experience} + \beta 10 \text{ off-farm activity} + \beta 11 \ldots \beta n\, xn + \varepsilon$$

Where;

Y = Chance of household which experience and not experience adoption technology

1 = If the household has adopted new technology

0 = If a household has not ever adopted new technology

Age = Age of respondents measured in years

Sex = (1 = If the household head is male, otherwise 0)

Household size = Number of household member

Education = Level of education attained by household measured in years of schooling

Farm size = Size of the farm possessed by household measured in acres
Farming experience = Number of years in paddy farming activities
Off-farm activity 1 = if household head engaged in other farming activities
0 = if otherwise
Credit access 1 = if household access credit
0 = if otherwise
Extension services 1 = if there is frequent contact with extension officers
0 = if otherwise
Market accessibility = distance from resident to the marketplace in km
α = Constant term ε = An error term. **β1**……… **β11** is the coefficient for variables

2.5.3 Qualitative data analysis

Qualitative data from focus group discussions and key informants interviews were analysed using content analysis technique. The data were interpreted and organized into different themes based on the conceptual description of ideas which was expressed by respondents during discussions.

3. RESULTS AND DISCUSSION

3.1 Socio-demographic Characteristics of Respondents

3.1.1 Sex and marital status

The sex of the respondents is an important factor for adoption of new agricultural technologies and practices in smallholder agriculture [1]. Female farmers are assumed to be less endowed with resources and consequently are disadvantaged when it comes to the adoption of agricultural technologies. Table 1 results show that more than half of the respondents (55%) were female while 45% were male. This implies that gender distribution among farmers in rainfed paddy production is skewed slightly towards females. The fact that more of respondents involved in this study were female was attributed by men's reluctance to participate in the study. Furthermore, rice production in the study area is carried out by women compared to their counterparts. Males concentrate on other activities such as fishing, lime and charcoal making or cultivation of cassava and oranges.

Table 1: Distribution of respondents by sex and marital status (n=120)

Variable	Category	Frequency	Percentage
Sex	Male	54	45.0
	Female	66	55.0
Marital status	Single	13	10.8
	Married	91	75.8
	Divorced	13	10.8
	Widowed	3	2.6

It is assumed that married couples are more likely to perform paddy farming and share experience in the adoption of agricultural technologies compared to single individuals. Antibioke et al.[18] asserted that crop production value chain and use of technologies are related to marital status. Hence marriage serves as a means of generating family labour. Findings in Table 1 show that 75.8% of respondents were married, 10.8% were single, 10.8% were divorced while 2.6% were widowed. The results imply that a proportion of the respondents were mature people with family responsibilities, which could encourage them to adopt agricultural technologies so as to increase paddy production.

3.1.2 Age

The mean age of respondents was 46 years; this means that there were a relatively high proportion of middle age paddy farmers among the respondents. Figure 3 shows that the largest proportions (40%) of respondents were within the age range of 40-49 years, followed by those of 50-59 years (22.5%), 30-39 years (16.7%), 60 years and above (12.5%) and lastly 19-29 (8.3%). Age of the respondents is associated with the adoption of new technology [Agbamu, 2006 as cited by Okunlola et al. [19]]. Age is often considered to be an indicator of willingness to adopt agricultural technologies and practices on the assumption that younger people are likely to adopt improved technological practices than old people [Akubuilo 1982 as cited by Atibioke et al., [18]]. This result indicates that the majority of farmers in the study area were in their active years of working, as more than three-quarters of respondents (79.2%) were between 30 and 59 years of age, a situation that is likely to favour the adoption of rainfed paddy technologies.

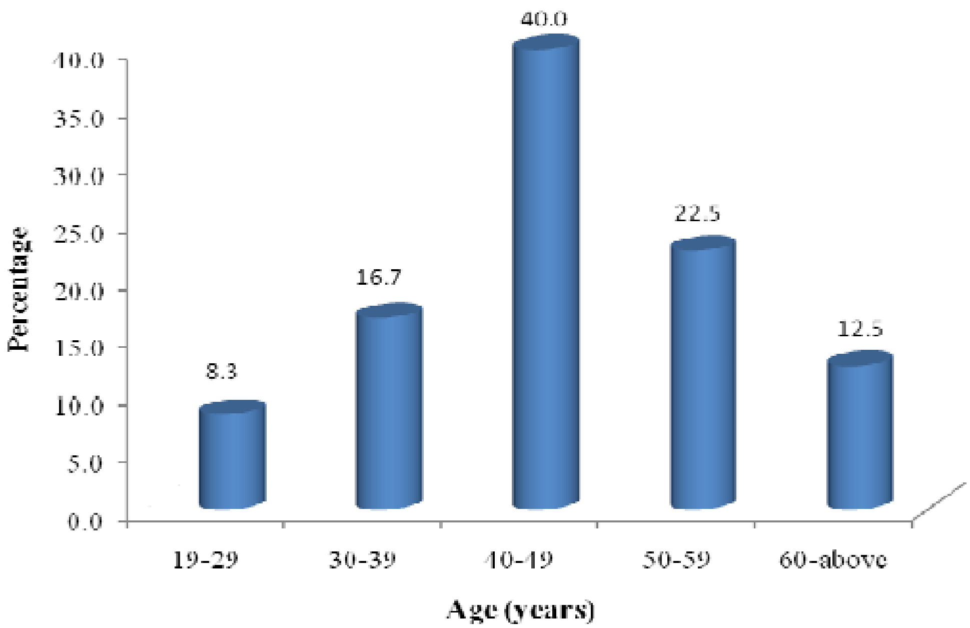

Figure 3: Distribution of respondents based on age (n=120)

3.1.3 Education level

It is assumed that literate farmers are better able to process information and search for suitable agricultural technologies to improve their production. As reported by Getahun et al. [2000] cited in Ayalew [20], adoption is anticipated to correlate positively with education. Table 2 result shows that 53.3% of the respondents had primary education, 19.2% of the farmers had no formal education, and very few (7.5%) had secondary education. This implies that majority of the farmers were literate, as 80.8% of them had one form or other forms of formal education. This means that high proportion of respondents were in a better position of being aware of, understanding and adoption of rainfed paddy production technologies.

Table 2: Respondents level of education (n=120)

Category	Frequency	Percentage
No formal education	23	19.2
Adult education	24	20.0
Primary education	64	53.3
Secondary education	9	7.5

3.1.4 Household size and farming experience

Table 3 results show that the largest household had 12 members and the smallest household had only one member. The mean household size was found to be 5.5 members. This is slightly higher than the Zanzibar national average household size of 4.5 members as revealed in the Population and Housing Census [21]. Results also show that households that had 1-4 members constituted 36.7%, followed by those with 5-9 members which constituted 53.3%, while those households with 10 or more members comprised of 10.0% of respondents studied. The relatively large household size could serve as a source of farm labour [22]. These findings reveal that farmers had relatively large-sized households that are advantageous to farming since it will enable farmers to use family labour for paddy production.

It was assumed that long farming experience was an advantage for increased farm productivity since it encourages rapid adoption of farm innovations. Kisusu [23] revealed that the number of years working on the farm develop technical know-how which is useful in the adoption of new technologies. About 34.2% of the respondents had farming experience of 11-20 years. The mean farming experience was 19.0 years. This means that respondents had a reasonable experience in farming that will enhance understanding and subsequent innovation of paddy production technology.

Table 3: Respondents' household size and farming experience (n=120)

Category	Frequency	Percentage
Household size (persons)		
1-4	44	36.7
5-9	64	53.3
10-above	12	10.0
Farming experience (years)		
1-10	42	35.0
11-20	41	34.2
21-30	17	14.2
31-40	10	8.3
41-above	10	8.3

3.1.5 Household occupation and off-farm income

During the study, respondents were asked about the major off-farm activities they undertake to generate income besides farming. Table 4 shows that 39.2% of the respondents were practicing farming as the only major occupation, 12.5% were engaged in casual labour and civil service respectively. This means that the majority of the respondents in the study area were farmers. It is assumed that involvement in off-farm income generating activities plays a big role in ensuring adoption of agricultural technologies. It was noted that the availability of off-farm income can offset credit constraints while enhancing the capacity to bear risk [24]. Mwagile 2001 cited in Mazengo [25] argued that off-farm activities complement farm productivity through increasing the farmers' capacity to procure agricultural inputs including improved seeds, fertilizers and pesticides.

According to Diiro [26], households with off-farm income had significantly higher adoption intensity and expenditure on purchased inputs relative to their counterparts without off-farm income. Also, it was noted that off-farm income significantly and positively increases the probability of adopting IPM technologies in cowpea, sorghum and groundnuts in Uganda [Bonabana-Wabbi and Taylor, 2012 as cited in Kirinya [27]]. The findings show that income generated from off-farm activities was mostly used to purchase foodstuffs, paying medical services and purchasing farm inputs. Use of off-farm income for the settling of debts was limited to a few households. This implies that farmers used a substantial amount of money generated from off-farm activities to purchase farm inputs, therefore, contributed to the adoption of agricultural technologies.

Table 4: Respondents' occupation and off-farm income (n=120)

Category	Frequency	Percentage
Occupation		
Farming only	47	39.2

Fishing	1	0.8
Casual labour	15	12.5
Civil servant	15	12.5
Business	41	34.2
Livestock keeping	1	0.8
Use of income from off-farm activities*		
To buy food	61	83.6
To purchase farm inputs	39	53.4
To settle debts	8	11.0
To pay for medical services	60	82.2

*Multiple responses provided

3.1.6 Farm size and farmland characteristics

Findings from Table 5 show that, all of the smallholder paddy farmers in the study area had access to land. About 95% of the farmers indicated that they have borrowed land from the government with the condition to grow paddy only and strictly not allowed to grow perennial crops. On the other hand, 3.3% inherited the land and only two (1.7%) rented the land to work for paddy farming. This implies that majority of the farmers depend on borrowed land from the government for paddy production. Table 5 results further revealed that 78.3% of the respondents experienced difficulties to acquire land for paddy production while 21.7% reported that it was easier for them to get land for paddy cultivation. This implies that majority of smallholder farmers in the study area experienced difficulties in acquiring land for paddy cultivation.

Results in Table 5 show that 82.5% of the respondents were found to cultivate on 0.1 to 2 acres of land for paddy production, 15.0% worked on pieces of land ranging between 2.1 to 3.0 acres, while only three (2.5%) worked on more than 3-acre plots. Most of the plots on which paddy is grown are small with the average farm size of 1.5 acres. This means that most of the farmers in the study area were smallholder farmers and the paddy on these plots is grown for subsistence. Empirical studies show that under smallholder farming, farm size is regarded as an important factor related to adoption and use of agricultural technologies [28]. Furthermore, Chirwa [29] stated that farm size exerts a positive influence on adoption of technologies. In addition, Abu et al. [30] reported that small farm size could be a factor which prevents farmers from adopting technologies because of the inappropriateness of modern technologies to the economic realities of small-scale farmers.

In addition Table 5 shows that only 4.2% of the respondents received agricultural credit, meaning that lack of access to credit facilities could hinder paddy farmers to purchase farm inputs, hence decreasing the adoption of technology. A number of studies have found that lack of credit does significantly impede adoption of high yielding varieties [31]. With respect to the distance taken to travel from residence to the nearest marketplace, the findings show that farmers had to travel an average of 2.0 km with a standard deviation of 1.43 km. The minimum and the maximum distance that a farmer had to travel to access marketplace were 0.5 km and 7.5 km, respectively.

Table 5: Respondents' farm characteristics (n=120)

Characteristics	Frequency	Percentage
Whether farmer has access to land		
Yes	120	100
No	0	0
Farm size (acre)		
0.1-2.0	99	82.5

2.1-3.0	18	15.0
3.1-4.0	1	0.8
4.1-5.0	2	1.7
Means of land acquisition		
Rented	2	1.7
Inherited	4	3.3
Government	114	95.0
Access to land for paddy production		
Very easy	3	2.5
Easy	23	19.2
Difficult	82	68.3
Very difficult	12	10.0
Access to credit		
Yes	5	4.2
No	115	95.8

Mean farm size owned = 1.5 acre, Range = 0.1 acre to 5 acre

Mean distance from home to the market place = 2.0 km, Minimum = 0.5 km, Maximum = 7.5 km

3.2 Adoption of Production Technologies in Rainfed Paddy Cultivation

Majority of respondents (79.2%) reported that government institution was the main source of obtaining advisory services (Table 6). Furthermore, 93.3% of respondents had contact with Block Extension Officers (BEO), whereas 6.7% had none. In addition, research findings show that 33.3% of respondents had contact with BEO once in a week, while 30.0% visited monthly followed by those who visited twice in a week.

About 80.4% of the visits, aimed at delivering advisory services to farmers were conducted during the occurrence of plant pests and diseases, 64.3% during provision of farm inputs (modern varieties, fertilizers and herbicides), 63.4% at sowing and 36.6% during the preparation of land for growing of paddy. This means that majority of farmers had contact with BEO and hence expected to be conversant with appropriate technologies in paddy farming. The main concern in agricultural research is to ensure research products are adopted by farmers [32]. Subsequently, farmers are expected to benefit from agricultural research findings by adopting technologies generated by research institutions [33]. Successful delivery of agricultural advisory services seemed to be imperative in increasing adoption of production technologies.

Results in Table 6 show that four types of paddy production technologies were identified to be disseminated to smallholder farmers for adoption in the study area. These were fertilizer application, weed control, sowing method and use of improved varieties. Block Extension Officers play a big role in promoting uptake and adoption of improved production technologies [34]. More than ¾ of respondents (88.3%) received advisory services on fertilizer application, 86.5% on weed control, and 82.9% on spacing while about 60.4% of the respondents reported to receive advice on improved varieties.

Following dissemination of paddy technologies by BEO, farmers in the study area were observed to adopt improved varieties (BKN Supa and TXD 88), fertilizers (Urea and TSP), herbicides (Basunil) and plant spacing (dibbling). In addition, during the Focus Group Discussions, most of the farmers said they were visited by Block Extension Officers and given different advice on the use of improved paddy production technologies. However, when asked what type of technology they used to practice in their paddy field, they pointed out that they use improved varieties, fertilizers (TSP and UREA), weeding through the use of herbicides and then hand weeding. The technology of planting by spacing was not used efficiently because it consumes a lot of time and difficulty in undertaking it as commented by most of the discussants. Bangura [1983] as cited by Alarima et al. [22] reported that farmers prefer to adopt technologies that required less time to use, and are less labour-demanding.

Table 6: Extension services and paddy technologies adopted by farmers (n=120)

Variables	Frequency	Percentage
Contact with Block Extension		
Yes	112	92.5
No	8	7.5
Frequency of visits		
Never	8	6.7
Once in a week	40	33.3
Twice in a week	32	26.7
Monthly	36	30.0
Yearly	4	3.3
Block Extension Visits*		
During land preparation	41	36.6
During sowing	71	63.4
During disease/pest occurrences	90	80.4
During harvesting	10	8.9
During farm inputs provision	72	64.3
Source of information		
Government	103	85.8
Contact farmer	17	14.2
Types of rainfed paddy production technologies farmers received from Block Extension Officers*		
Method of paddy sowing	92	82.9
Paddy variety	67	60.4
Fertilizer application	98	88.3
Method of weed control	96	86.5

*Multiple responses provided

3.3 Extent of Adoption of Rainfed Paddy Production Technologies

The study sought to assess the extent of rainfed paddy production technologies to smallholder farmers in the study area. In this case, the percentage of respondents practicing new paddy production technologies were used. According to Rogers and Shoemaker [1971] as cited by Oladele [35], adoption of technologies refers to the decision to apply technology and to continue to use it. Table 7 shows that the extent of adoption of fertilizer, improved varieties, plant spacing was high among smallholder farmers in the study area. The results show that all respondents applied top dressing (application of UREA fertilizers (average 50 kg/acre). Such findings are in line with those of Mkojera [36] who found all farmers interviewed, applied fertilizers in paddy at Mombo irrigation scheme. Also, it was found that 70.2% of the interviewed applied basal fertilizer (50 kg/acre of TSP) in their paddy field. Majority of the respondents (76.7%) also adopted herbicide and hand weeding; only hand weeding (19.2%) and only herbicides (4.2%).

It was also noticed that 74.2% of farmers adopted improved varieties only such as TXD 88 and BKN Supa, those who grow local and improved varieties (17.5%), 8.3% local varieties only and 60.8% adopted row planting (20 cm x 20 cm). This is contrary to the findings of the study by Mwaseba [37] which revealed that 60.4% of the respondents planted local varieties. Many of the farmers adopted improved paddy production technologies because fertilizers and improved paddy varieties were provided at a subsidized price by the government.

Table 7: Extent of adoption of recommended paddy production technologies (n=120)

Technology	Frequency	Percentage
Method of paddy sowing		
Row planting (dibbling)	73	60.8
Broadcasting	21	17.5
Both	26	21.7
Paddy variety		
Local	10	8.3
Improved	89	74.2
Both	21	17.5
Method of Fertilizer application*		
Basal application	80	70.2
Top dressing application	114	100.0
Method of weed control		
Herbicide use	5	4.2
Hand weeding	23	19.2
Both	92	76.7

*Multiple responses provided

3.3.1 Challenges in paddy production

The extensive adoption of improved production technology is normally enhanced through favourable government policy, accessibility to agricultural credit, intensive extension services and the availability of farm inputs, especially fertilizers and herbicides [38]. Although the foregoing description shows that the overall adoption of paddy production technologies is high, farmers' efforts to increase paddy production are confronted by a number of challenges. These include incidence of plant pests and diseases, inadequate provision of tractor services for land preparation, timely availability of agricultural inputs (fertilizers and herbicides), poor access to credit and unreliable rainfall because of climate change (Table 8). Highest responses were the inadequate provision of tractor services and incidence of pests and plant diseases scoring 53.8%, followed by untimely availability of agricultural inputs such as fertilizers, herbicides and improved varieties with 53.0%. Other challenges are poor access to credit to support paddy production and unreliable rainfall which scored 21.4% and 17.9% respectively as indicated in Table 8. This was supported by the information from FGDs and KI who also noted the same challenges as one of the middle-aged farmer in the study area raised his voice: "I am worried if I will get enough harvest this year. Paddy is in the flowering stage, I did not apply fertilizer yet and I found there is nothing in Kilimo shop". These results are in conformity with findings obtained in Zanzibar Agricultural Transformation for Sustainable Development [39].

Table 8: Distribution of respondents based on adoption/production challenges

Paddy production challenges	Responses*	
	Number	Percentage

Agricultural Input related constraints	62	53.0
Inadequate tractor services	63	53.8
Poor access to credit	25	21.4
Incidence of pest and plant diseases	63	53.8
Unreliable rainfall	21	17.9

*Multiple responses provided

The increase of paddy productivity could be attributed to the wide adoption of the improved paddy production technologies and other recommended management practices. It may also be due to the adoption of good policies such as credit, input supply, land tenure, market research, and extension that are conducive for paddy production. Smallholder farmers need adequate amounts of appropriate farms inputs at the right time in order to obtain higher productivity in paddy cultivation. On the other hand, several factors could affect paddy productivity. These factors include drought, pest outbreak, weed infestation, low soil fertility and postharvest management. Hence, to obtain higher productivity in paddy cultivation, it requires having favourable paddy policies, using the recommended practices coupled with intensive crop management and monitoring of production constraints facing the smallholder farmers.

3.4 Major Factors Influencing Adoption of Technologies

The binary logistic regression model was used to determine the socio-economic and farmer characteristics affecting the adoption of rainfed paddy production technologies. The dependent variables were the adoption of individual components of the technology package. Farmers in the study area were found using row planting, chemical fertilizers, herbicides and improved varieties in their paddy field. The number and type of independent variables differ with each dependent variable (adoption of individual paddy production technologies). Also, number and type of independent variables were selected on the basis of the importance of relationships to the dependent variables.

3.4.1 Logistic model estimates for row planting

Table 9 shows that two out of the six selected variables hypothesized to influence adoption of planting spacing in the study area had significant coefficients at $p<0.05$. These are extension services and age. Extension services have the highest influence on adoption of plant spacing with a logistic coefficient of 3.05, p-value = 0.00 and Wald-statistic = 10.28, implying that contacts with Block Extension Officers have great impact on the adoption of row planting. As reported earlier, 92.5% of the respondents in the study area reported to have contact with Block Extension Officers (Table 6) and among them, 60.8% adopted row planting technology (Table 7).

The results further show that age of the respondents had a coefficient of -0.07 at p-value = 0.02. The results indicate a negative but significant relationship between adoption of row planting and age. This implies that older farmers have poor chances of applying row planting compared to younger farmers. This concurs with findings by Tiwari et al. [40] and Mwaseba et al. [37] who found that the age of the household head is negatively related to the adoption of technology. In addition, this finding concurs with CIMMYT [17] that age has a substantial influence on either use or nonuse of any new technology introduced in a certain area. The variable marital status was found not significant, implying that being married or single does not matter for the adoption of row planting technology.

Table 9: Logistic analysis for factors influencing adoption of row planting

Variables	Coefficient	S.E.	Wald	Sig.
Age (years)	-0.07	0.03	5.81	0.02*
Sex	0.83	0.62	1.80	0.18
Education	-0.58	0.79	0.54	0.46
Marital status	0.88	0.62	2.01	0.16
Farm size (acre)	-0.41	0.59	0.49	0.48

Extension services	3.05	0.95	10.28	0.00**
Constant	1.79	1.60	1.26	0.26

-2 Log likelihood = 86.89, Cox & Snell R2 = 0.18, Nagelkerke R2 = 0.30

Hosmer and Lemeshow Test: Chi-square = 5.88, d.f = 8, Sig. = 0.66

Overall percentage of right prediction = 87.5%, Sample size = 120

Note ** = significant at p<0.01, * = significant at p<0.05

3.4.2 Logistic model estimates for fertilizer application

The results of the logistic regression model are presented in Table 10. The model predicted that there was the statistically significant influence of off-farm income on adoption of fertilizer application at p-value = 0.03 and Wald-statistic = 4.82, implying that those smallholder farmers with off-farm income have higher flexibility to invest in new technology such as to procure fertilizers than those who rely on farm income. Furthermore, the model results indicated that the age of respondents is statistically significant at p-value = 0.04 and positively related to the adoption of fertilizers in the study area. This implies that there is a greater likelihood of the older farmers to invest in fertilizer application as compared to younger ones. This finding corroborates similar ones by Boz et al. [41] who reported that age of respondents was positively and statistically significantly associated with adoption of dairy farming technologies in Eastern Mediterranean Region of Turkey. Moreover, CIMMYT [17] revealed that older farmers may have more experience, resources, or authority that would allow them more possibility for trying a new technology.

Table 10: Logistic analysis for factors influencing adoption of fertilizer application

Variables	Coefficient	S.E.	Wald	Sig.
Age (years)	0.07	0.03	4.33	0.04*
Off farm income	2.25	1.03	4.82	0.03*
Market distance (km)	-0.46	0.30	2.41	0.12
Education	0.69	0.93	0.56	0.46
Marital status	0.53	0.86	0.38	0.54
Constant	-0.96	1.90	0.25	0.61

-2 Log likelihood = 43.98, Cox & Snell R2 = 0.12, Nagelkerke R2 = 0.30

Hosmer and Lemeshow Test: Chi-square = 13.88, d.f = 8, Sig. = 0.09

Overall percentage of right prediction = 92.4%, Sample size = 120

Note * = significant at p<0.05

3.4.3 Logistic model estimates for herbicide application

The adoption of herbicide was influenced by the age of smallholder farmers and extension services (Table 11). The analyses show that at p-value = 0.05 and logistic coefficient of – 0.16, farmers' age is negatively related to the adoption of herbicide, suggesting that the probability adopting the technology is lower among older farmers than younger ones. As hypothesized, extension services had a significant effect on herbicide adoption. Extension service is positively and significantly correlated to use of herbicide to manage weeds in the paddy field. The model shows that extension services increased the probability of adoption of herbicide by 2% in the study area. This is based on the fact that access to extension services enables farmers to get exposed and more conversant with the use of herbicide. This result is in line with Kirinya et al. [27] who reported that receipt of extension services positively and significantly influences integrated pest management technologies in Uganda.

Furthermore, Akil and Bryant [42] asserted that access to extension services had a greater influence on the adoption of Artificial Insemination in Zanzibar. It was noted that extension service is one of the prerequisites for creating awareness and building the necessary knowledge for farmers to use the new technology [43]. Other factors hypothesized to influence adoption did not have significant coefficients at p-value = 0.05 probability level in explaining the adoption decision. They included marital status, market distance, off-farm income and farming experience.

Table 11: Logistic analysis for factors influencing adoption of herbicides

Variables	Coefficient	S.E.	Wald	Sig.
Age (years)	-0.16	0.08	3.93	0.05*
Paddy farming experience	0.09	0.07	1.43	0.23
Extension services	4.73	2.10	5.08	0.02*
Marital status	-19.40	5535.13	0.00	1.00
Off farm income	-1.02	1.46	0.49	0.48
Market distance (km)	-0.40	0.37	1.14	0.29
Constant	26.72	5535.13	0.00	1.00

-2 Log likelihood = 17.06, Cox & Snell R2 = 0.09, Nagelkerke R2 = 0.42

Hosmer and Lemeshow Test: Chi-square = 2.5, d.f = 8, Sig. = 0.96

Overall percentage of right prediction = 98.3%, Sample size = 120

Note * = significant at p<0.05

3.4.4 Logistic model estimates for improved paddy varieties

Extension services and distance from resident to the marketplace were significantly associated with adoption of improved varieties in the study area at p<.05. However, the age and education level of the smallholder farmers were not associated with the level of adoption of improved varieties at p<0.05. Table 12 shows that the extension services had a coefficient of 2.17 at p = .02. This means that provision of extension services to the smallholder farmers encouraged the adoption of the improved varieties, this is probably due to the fact that exposure to information reduces subjective uncertainty about technology. This is consistent with the findings of Bisanda et al. [44] who found that the extension contact was significantly associated with the adoption of improved maize varieties in the Southern Highlands of Tanzania.

Table 12: Logistic analysis for factors influencing improved paddy varieties

Variables	Coefficient	S.E.	Wald	Sig.
Extension services	2.17	0.89	5.91	0.02*
Market distance	-0.45	0.21	4.36	0.04*
Age	0.00	0.03	0.01	0.93
Sex	0.24	0.73	0.11	0.74
Education	0.38	0.90	0.18	0.67
Constant	1.30	1.78	0.54	0.46

-2 Log likelihood = 53.31, Cox & Snell R2 = 0.08, Nagelkerke2 = 0.20

Hosmer and Lemeshow Test: Chi-square = 10.78, d.f = 8, Sig. = 0.21

Overall percentage of right prediction = 93.3%, Sample size = 120

Note * = significant at p<0.05

Results in Table 12 also indicate that market distance, which is a proxy for market inaccessibility, is found to have a negative and significant relationship with the chance of adoption of improved paddy varieties at p = .04. This implies that smallholder farmers far away from marketplaces are less likely to adopt improved paddy varieties than those who are located near the marketplaces. The possible explanation for this is that smallholder farmers, who are far away from marketplaces experienced poor access to farm inputs and other technologies, hence limit adoption of technologies. Similar results were reported by Ayalew [20], as market distance increases, adoption decreased.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

This study has identified fertilizer application, a method of weed control, row planting and use of improved paddy varieties as the major rainfed paddy production technologies disseminated and adopted by smallholder farmers in the study area. Descriptive statistical analysis results show that most of the paddy farmers in the study area were literate and middle-aged, and having a mean family size of 5.5 members. Majority of the respondents had reasonable experience in paddy farming and worked on a small piece of land. However, the majority of the respondents did not receive credit for paddy production. It can be concluded that the level of technologies was high unlike the findings of other relevant studies, this study, therefore, assumes that the higher adoption rate was attributed to the availability of extension services in the study area. However, rainfed paddy production technologies adoption had no significant impact on productivity due to other challenges affecting paddy production such as untimely availability of farm inputs, unreliable rainfall and incidence of pest and plant diseases.

Logistic regression analysis results revealed that farmer's age, extension services, off-farm income and market distance have significantly influenced the chances of farmers to adopt rainfed paddy production technologies. These results support the hypothesis that farmers decision to the adoption of rainfed paddy production technology depends on their social-economic and farmer characteristics.

4.2 Recommendations

The following recommendations are suggested towards increasing sustainability in the adoption of rainfed paddy production technologies in the Central District:

- The extension services had a greater influence on the adoption of technology, therefore the Ministry of Agriculture and Natural Resources should continue providing efficient and effective extension services to smallholder farmers in the study area.

- To make the rainfed paddy production technologies adoption more successful and sustainable, the Revolutionary Government of Zanzibar should allow credit to be offered without collateral to enable smallholder farmers to afford to buy farm inputs (fertilizers, herbicides, improved paddy varieties and tractor services).

- The Ministry of Agriculture and Natural Resources needs to improve timely availability of farm inputs to fit with the paddy cultivation activities calendar.

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APPENDICES

Appendix 1: Household Questionnaire

ADOPTION OF RAINFED PADDY TECHNOLOGY AMONG SMALLHOLDER FARMERS IN THE CENTRAL DISTRICT-ZANZIBAR

PART ONE

Questionnaire number…………….. Interview date……………………………………
Name of the district...
Name of the Shehia…………………...

PART TWO: HOUSEHOLD BACKGROUND CHARACTERISTICS

1.Name of the respondent :*(Option*)……………………………………………………
2.Age of the respondent………………………… (years).
3.Sex of the respondent: (Tick the appropriate)
1= Male ( ) 2=Female ( )
4.Number of year spent in formal school……………………………….(years).
5.Occupation: 1= Farmer ( ) 2 = Non farmer ( )

6.Marital status :(Tick the appropriate)
1=Single (   ) 2=Married (   ) 3=Divorced/separated (   ) 4=Widowed (   )
7.Household family size

SN	List of family members	Sex 1=Male 2=Female	Age
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			

PART THREE: HOUSEHOLD, FARMING AND SOCIO ECONOMIC CHARACTERISTICS

8.For how long (years) have you been engaged in paddy farming?…………………
9.Do you have off-farm activities apart from paddy farming? (Tick the appropriate)
1=Yes (   ) 2= No (   )
10.If yes, what type of activity are you engaged for? :(Please tick the appropriate)
1=Fishing (   ), 2=Casual labour (   ) 3= civil servant (   ), 4= business (   ), 5= Others (specify)………………………………………………………………………
11.For what purpose do you use the income from off-farm activities?
1= to buy food (   ) 2= to purchase farm inputs (   ) 3= to settle debts (   ) 4=to pay for medical services (   ) 5=Others (specify)…………………………………………
12.How easy to get land for paddy production in the Shehia? (Tick one)
(a) Very easy (no conditions to get the land) (   )
(b) Easy (few conditions to get land) (   )
(c) Difficult (strong conditions to get the land) (   )
(d) Very difficult (very strong conditions to get the land) (   )
13.Do you have access to land for paddy farming?
1=Yes (   ) 2= No (   )
14.How many acres of paddy field do you posses?...
15.How did you access land for paddy farming?
1= Purchased (   ) 2= Rented (   ) 3= Inherited (   ) 4= Lease (   ) 5= Others (specify)………………………………………………………………………

PART FOUR: EXTENSION SERVICES AND TECHNOLOGY ADOPTION

16.Do you get any advisory services from extension officers?
1=Yes (   ) 2=No (   )
17.From which source(s) do you get the extension advice?
1=Government system (   ) 2=Contact farmer (   ) 3= NGOs (   )
4=others (specify)………………………………………….
18.What types of services did you receive from extension officers?
1=Plant spacing (   ) 2= paddy variety (   ) 3= fertilizer application (   )
4=weed control (   ) 5= others (specify)…………………………………………
19.How frequently do the extension officers visit you?
1) Never (   ) 2= Once in a week (   ) 3= twice in a week (   ) 4= monthly (   ) 5= yearly (   )
20.When do extension officers visit you?
1) During land preparation (   ) 2= During sowing (   ) 3= When disease/pest occur (   )
4= during harvesting (   ) 5= During farm inputs provision (   )

21.Which method of sowing you use in paddy cultivation?
    1=row planting (   ), 2= broadcasting (   ), 3 = both (   )
22.Which paddy variety do you use?
    1= Local variety (   )   2 = Improved (   )   3= Both (   )
23.Did you apply fertilizer in your paddy field? 1= Yes (   )   2= No (   )
24.If answer in question 22 is yes, which type of fertilizer did you use?
    1= TSP (   ), 2=urea (   ), 3= organic (   )
    others (specify)……………………………
25.Did you come across weed problem in paddy cultivation? 1= Yes (   ), 2= No (   )
26.If yes how, did you solve this problem?
    1= using herbicide (   )   2= hand weeding (   )

PART FIVE: CREDIT AND MARKET ACCESSIBILITY

27.Have you obtained credit for paddy production? 1) Yes (   ) 2= No (   )
28.If yes in question 24 what are the source of fund? (Tick appropriate)
    1= Loan from bank (   )   2=saving and credit association (   )
    3= others source (specify)……………………………………………….
29.For what purpose did you use the credit? 1= for purchasing improved seeds (   )
    2=for purchasing fertilizers (   ) 3=for purchasing herbicides (   )
    4=others (specify)…………………………………………………………..
30.Is there any market availability for farm inputs?
    1=Yes (   ) 2= No (   )
31.If yes in question 27 above, how many km from the market……………………………
32.Mention the most important challenges/constraints that you face in paddy production?
1…………………………………
2…………………………………
3………………………………….
4………………………………….
5……………………………........

Appendix 2: Interview Checklist for District Agriculture Development Officer and Extension Officers

1. For how long (years) have you been providing advisory services to smallholder farmers?
2. Do you have contacts with rainfed paddy smallholder farmers?
3. How frequently do you visit smallholder farmers in their paddy field?
4. When do you visit farmers during rainfed paddy cultivation activities?
5. What types of paddy technologies provided to smallholder farmers?
6. What variety of seeds do smallholder farmers use in paddy farming?
7. Which method do smallholder farmers use in sowing paddy?
8. Did smallholder farmers apply fertilizer in their paddy field?
9. What type of fertilizer do smallholder farmers use?
10. Which method of weed control in paddy farming practiced by smallholder farmers?
11. At what level rainfed paddy technology adopted by smallholder farmers?
12. On your opinion, what do you think are the factors that influence the adoption of rainfed paddy technologies by smallholder farmers?
13. What are technologies/recommendations being promoted through extension?
14. Which approach/methodology being used to promote these technologies?
15. What is the extent of farmers’ response to the extension efforts?
16. Which challenges do extension staffs face?
17. What kinds of problems are there with respect to availability of inputs and outputs markets?