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The Effect of adoption of agricultural sustainable intensification practices on the Mwea rice farmers' yields and income in Mwea Irrigation Scheme

Joseph Maina Ndung'u
Strathmore Business School
Strathmore University

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**THE EFFECT OF ADOPTION OF AGRICULTURAL SUSTAINABLE
INTENSIFICATION PRACTICES ON THE MWEA RICE FARMERS'
YIELDS AND INCOME IN MWEA IRRIGATION SCHEME.**

BY

JOSEPH MAINA NDUNG'U

**A Dissertation Submitted to the Strathmore Business School in Partial Fulfilment
of the Requirement for the Degree of Master in Management of Agribusiness.**

**STRATHMORE BUSINESS SCHOOL
STRATHMORE UNIVERSITY
NAIROBI, KENYA**

November, 2021.

STUDENT'S DECLARATION

I, the undersigned, declare that this Dissertation is my original work and has not been submitted to any other college, institution or university other than the Strathmore University, School of Business for academic credit.

Signed: 

Date: 4th November, 2021.

Joseph Maina Ndung'u (Reg. No. 102221)

This dissertation has been presented for examination with my approval as the appointed supervisor.

Signed: _____

Date: _____

Prof. Simon Wagura Ndiritu.

Signed: _____

Date: _____

Dean, Strathmore Business School

ABSTRACT

The purpose of this study was to investigate the effect of adopting agricultural sustainable intensification practices with relation to rice farmers' yields and income with the aim of increasing rice yields and profitability and ultimately reducing rice imports in Kenya. The study was quantitative and analysed using descriptive statistical methods, the data collected was mainly quantitative since it was mostly numerical and discrete. The study was a cross-sectional one and survey research strategy was used. The study used stratified sampling method (i.e. adopters' vs non-adopters) and examined a sample of 400 small scale rice farmers out of the 3,200 active farmers derived from the irrigation scheme. The study used both primary and secondary data and the primary data was collected using questionnaires to guide the interviews on the respondents. Simultaneously the secondary data was mainly from journals, periodicals, textbooks and reports by relevant institutions. The data was analysed statistically by use of OLS model with the STATA software and results were presented descriptively as mean, mode, median, percentages and frequencies presented in graphs, tables, charts, percentages and cross tabs.

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ABBREVIATIONS AND ACRONYMS

ASIPs- Agricultural Sustainable Intensification Practices.

MRGM – Mwea Rice Growers Multipurpose Co-operative Society ltd.

ARC – Africa Rice Centre.

NIB – National irrigation Board.

GRiSP – Global Rice Science Partnership

MOA – Ministry of Agriculture

NRDS – National Rice Development Strategy

NERICA – New Rice for Africa.

SRI – System Rice Intensification practices.

WSRC – Water Saving Rice Culture.

Mt – Metric tonne

Gok – Government of Kenya.

RIPP- Rice Promotion Programme

KARI – Kenya Agricultural Research Institute.

JICA - Japan International Cooperation Agency

FAO – Food and Agriculture organization.

TICAD - Tokyo International Conference on African Development

Kg – kilo gram.

Ha – Hectare = 2.5 acres.

CHAPTER ONE

1.0 Introduction

1.1 Background of the Study

Rice (*Oryza* spp.), belongs to the genus *Oryza* which has 23 species, of these species, 21 are wild whereas 2 are cultivated; *O. glaberrima* and *O. Sativa* L (Khush, 1997; Khush et al, 2000). The latter is widely grown worldwide (Vaughan et al., 2008). The crop is grown under five production systems which are irrigated lowland, rainfed lowland, deep-water systems, mangrove swamp and rainfed upland system (Olembo et al., 2010). Worldwide irrigated lowland ecosystem remains the main source of rice supply (Pascual & Wang, 2016). Rice is staple food for more than half of world's population, contributing over 20% of the total calorie intake for humans. The leading producers of this cereal are China, India, and Indonesia (Food and Agriculture Organization, 2020). In sub Saharan Africa, rice production is increasing by 3.2 % per year but annual consumption is growing faster at a rate of 5.5 % with the balance being met by increasing quantities of imports (International Rice Research Institute, 2013).

In Kenya rice is the third most important staple food crop after maize and wheat mainly grown under irrigated and rain fed conditions (Ministry of Agriculture, 2009). Under irrigated conditions, rice has been grown mainly in government established irrigation schemes managed by National Irrigation Board (NIB). These are Ahero, Bunyala, West Kano irrigation schemes in western Kenya, Bura and Hola in coastal region and Mwea irrigation scheme (MIS) in central Kenya (Karina & Mwaniki, 2011, p. 10). Rice crop has been generally produced as a cash crop but with increasing population, changes in eating habits, and urbanization, the country has witnessed tremendous increase in rice consumption (Mati et al., 2011). The annual rice consumption exceeds production by about 70% creating a deficit which is met through imports. It has been anticipated that demand for rice in the country will continue to increase at a rate of 12% as compared to 4% for wheat and 1% for maize (Ministry of Agriculture, 2009). This therefore has made it important to increase the local production of rice in saving the country's import costs.

Partly a combination of the conventional paddy cultivation system and water scarcity in the major rice irrigation schemes in the country has resulted to reduction in rice production and productivity causing negative effect on the livelihoods of rice farmers. For example, production of rice decreased from 138, 204 tons in 2012 to 81,200 tons in 2017 (Government of Kenya, 2018, p. 43). This was due to the prolonged dry spell in 2017 which reduced water availability.

Yields of irrigated rice oscillate between 3.5 t ha⁻¹ to 4 t ha⁻¹ far below the optimum of about 7 t ha⁻¹ (Food and Agriculture Organization, 2020). In the last decade, it has necessitated to introduce ASIP's that utilize less water while also raising productivity (Mati et al., 2011). Sustainable intensification practices has aimed at making better use of existing resources (e.g. land, water and biodiversity) and technologies to enhance the productivity and resilience of agricultural production systems without adverse environmental impact and without the cultivation of more land, thus guaranteeing production and agricultural revenue for the farmers (Pretty, 1997). The introduction of ASIP's have been because of the: climate change famously known as global warming (change of weather patterns, ice melting, sea levels changing, erratic rainfall, high temperatures, cold seasons, drought etc.) which has jeopardized agricultural production; pressures from industrial development competing with agricultural land leading to unavailability of land for production; high population growths demanding more food; emergence of new strains of diseases and pests affecting the farming systems among other factors. Climate change has adversely affected water availability negatively leading to droughts, this has made rice production unpredictable and riskier and ultimately crop failure. Some of the practices introduced in farming to counteract climate change in various value chains include: precision agriculture, organic farming and conservation agriculture etc.

Two rice sustainable intensification practices have been invented i.e.; system for rice intensification (SRI) (Mati et al., 2011) and water saving rice culture (WSRC) (Rice Mapp Flash, 2015) and was introduced and adopted by farmers in Mwea Irrigation scheme geared towards sustainable rice farming.

The SRI is a package of practices developed to improve the productivity of rice grown in paddies. Unlike the conventional method of continuous flooding of paddy fields, SRI involves intermittent wetting and drying of paddies as well as specific soil, nutrient, mechanical weeding and agronomic management practice. The WSRC is a modification of SRI introduced to the scheme by Japan International Cooperation Agency (JICA) through Rice-based and Market-oriented Agriculture Promotion project in 2014 (Rice Mapp Flash, 2015). This technique aimed at improving rice production while reducing cost in production, improving farmer's income by introducing other crops and intensification by water saving techniques. The WSRC involved transplanting of 21 days old seedling in a wider spacing (30cm x 15cm), line planting 2 to 3 seedling per hill and additional modified split application of chemical fertilizers. The crop was managed under intermittent irrigation with mechanized weeding and harvesting.

Since its introduction, SRI practice has been widely promoted globally. Numerous studies have

reported significant positive impact of SRI on rice yield and income of small-scale farmers growing rice. In India, rice yield under SRI practices was higher than under conventional practice by 42% in eastern region (Thakur et al., 2010), and 210% in eastern Himalayas region reporting an income of 765 USD/ha higher than the common practice. (Ricepedia, 2019) In Indonesia SRI use increased rice yields and income per hectare by 64% and 107% respectively (Takahashi & Barrett, 2014). A study by (Majiwa, 2017) directly involving 3600 small-scale farmers in Thailand and Cambodia, reported rice yields of 60 to 100% higher than the average yield in the region. In region of Mali, average SRI yield was 9.1 t ha⁻¹, 66% higher than the average for control plots at 5.5 t ha⁻¹. The net revenue for SRI was 2,220 USD/ha compared 1,089 USD/ha for the conventional practice (Africare, 2010). In Tanzania, Mkindo area, for a spacing of 25 cm by 25 cm, the grain yield was 6.3 t ha⁻¹, which was higher than conventional practice, which recorded a yield of 3.83 t ha⁻¹ (Kombe, 2012).

A few studies on the effect of SRI management practices on farmers' yields and income have also been reported in Kenya. In west Kano irrigation scheme of western Kenya, SRI was used on different rice varieties and had increased grain yield ranging from 33 to 53% compared to the conventional paddy system (Mwatete et al., 2017). In Mwea irrigation scheme rice grown under SRI versus conventional practice showed that there was increased by 11 %, 16 % and 51 % for Basmati 370, IR 2793-80-1 and BW 196 respectively (Ndiiri et al., 2012). Later studies in MIS also reported that SRI use increased yields per hectare by 33% (Ndiiri et al., 2013) and 46 % (Omwenga et al., 2014), and net income increased by 145% (Ndiiri et al., 2013); however the most significant components of SRI were not linked to this. Test experiments on WSRC with 21 selected farmers during the short rain season of 2014 reported the average yield and profit increased from 13% and 10%, respectively (Mwithia et al., 2015). However, there were no differentiation of which components of the practices that caused increase in yields and income. The WSRC was introduced in 2014 and farmers continued to adopt the practice. Rice growers of Mwea Rice Growers Multipurpose (MRGM) Co-operative Society Ltd. were among the beneficiaries of these improved technologies. Field observations have shown that while some farmers had adopted SRI and WSRC, others were still practicing the conventional paddy systems. Even among the adopters of SRI and WSRC only partial components were practiced. Although reports confirm that SRI and WSRC use generated increased rice yield and income, the impact of these improved practices is yet to be realized among the MRGM farmers and the nation at large by reduction of imports into the country, (Mati, 2011).

According to Omwenga, (2014) Socio-economic characteristics of the farmers tend to influence

the adoption of a given practice in farming; younger farmers tend to adopt new practices easily compared to the older farmers. In addition, male farmers seem to adopt new technologies faster compared to female farmers due to more access to capital of production which female farmers tend to lack. Educated farmers' analyzed a practice more easily and decided to adopt it as compared to uneducated farmers. Farmers in organized groups have a strong sense of protection in trying a new practice compared to farmers who were not in organized groups. Socio-economic characteristics affects adoption of sustainable intensification practices in rice farming in Mwea irrigation scheme, therefore, there is need to determine the influence of specific components of SRI and WSRC practices on Mwea rice farmer' rice yield and incomes and role of socio-economic factors on the realized their yields and incomes. This information requires to be availed so that the rice farmers in Mwea and other rice schemes, other stakeholders may make informed decision on how to better the yield outcomes and bring about improved incomes and what components are significant to rice yields and income (Mwatete, 2017)

1.2 Problem statement

Rice consumption in Kenya has been tremendously increasing with the rise in population, urbanization and changes in eating habits. Currently the annual rice consumption exceeds production by about 70% creating a deficit which is met through imports. Since 2008, the import bill had tripled to about US\$ 260 million per annum (Food and Agriculture Organization, 2020) and yet an increase in yields is reported due to the adoption of ASIPs in rice schemes. The revenue used to import the deficit is benefiting farmers from other countries yet the local farmers languish in poverty due to low returns from their hard labour, and flooded markets with cheap rice imports yet it's reported that ASIPs resulted in increased incomes. To achieve a total domestic rice production of 9.31% per annum (Ministry of Agriculture, 2009, p. 12), interventions that increase production and productivity through reduction of farmers cost of production and sustainable utilization of existing resources need to be promoted.

The Mwea Irrigation Scheme (MIS) covers an area of 12,000 ha. Out of these, about 9000 ha are under paddy rice production and yet it cannot satisfy the annual rice consumption even after adoption of ASIPs (National Irrigation Authority, 2020). Rice production in the scheme has mostly been based on the conventional practices of continuously flooding the paddy fields, broadcasting pre-germinated seeds or use of smaller spacing per hill (Mwatete et al., 2017). A combination of the conventional paddy system and water scarcity has resulted to reduction in rice production and productivity causing negative effect on the livelihoods of the farmers growing rice in the scheme. According to NIB, (2019) the average income of a rice farmer in

Kenya under conventional paddy production is estimated at ksh 60 per kg against a cost of production of ksh 55 per kg therefore the rice farmers generally have low incomes and hence low living standards. Two ASIPs; System for rice intensification (SRI) (Mati et al., 2011) and water saving rice culture (WSRC) (Rice Mapp Flash, 2015) that improves rice productivity while minimizing water uses were introduced in the scheme through multi-stakeholder, participatory 'project' combining research, capacity-building and outreach activities yet the most significant components to yields and income are not researched on. To date over 2000 small scale farmers have adopted these improved agricultural practices, numerous studies have confirmed that SRI use generates increased yield and income per unit of cultivated area (Thakur et al., 2010; Takahashi & Barrett, 2014; Ndiiri et al., 2013; Omwenga et al., 2014). However, the effect of both practices are generalized and little is done to show the most significant components of these practices to rice yields and income for the farmers to adopt and avoid practicing insignificant practices and components. In addition, since inception of these practices there has been modifications and incorporation of mechanization and its effect have not been researched on. Therefore, this study intended to investigate the effects of adopting SRI and WSRC on rice farmers' yields and income and the role of socio-economic factors on the realized rice yields and incomes. The target population was rice farmers who are members of the MRGM, the leading rice cooperative in Kenya with over 5000 farmers accounting for 20% of all the small-scale farmers growing rice in Mwea Irrigation scheme.

1.3 Research objectives

1.3.1 General objective

To investigate the effect of adopting agricultural sustainable intensification practices in rice farming aimed towards improving farmers' yield and income.

1.3.2 Specific objectives

1. To investigate the effects of adopting SRI on rice farmers yields and income in Mwea irrigation scheme
2. To determine the effects of adopting WSRC on rice farmers yields and income in Mwea irrigation scheme
3. To determine the effects of socio-economic factors on farmers yields and income in Mwea irrigation scheme

1.4 Research Questions

1. What was the effect of adopting SRI practices in rice farmers' income in Mwea rice scheme?
2. What was the effect of adopting WSRC practices in rice farmers' income Mwea rice scheme?
3. What was the relationship between socio-economic characteristics and rice farmers' income in Mwea scheme?

1.4.1 Hypotheses

1. There was increased rice yields and income for small scale farmers who have fully or partially adopted the recommended SRI practices.
2. There was increased rice yields and income for small scale farmers who have fully or partially adopted the recommended WSRC practices
3. Small scale farmers' rice yields and incomes was hinged on socio economic factors

1.5 Scope of the study

The study focused on small scale farmers growing rice in Mwea irrigation scheme within Kirinyaga County, Kenya. The study examined 400 farmers from across the Mwea Rice Scheme and the survey was conducted between February 2020 and March 2020. Stratified random sampling of the schemes' farmers was done based on the members of the Mwea Rice Growers Multipurpose Cooperative Ltd (MRGM).

1.6 Significance of the Study

1.6.1 The Rice Mwea Scheme

The study was first and foremost important to the Rice Farmers at the Mwea Rice Growers Scheme. It was beneficial to the farmers to better understand the importance of ASIP's and how these can be deployed to better the yield outcomes and bring about improved incomes

1.6.2 Private Stakeholders

This study highlighted the many advantages that ASIP's can bring to farm yields and in the long run, also impact farmers' income. The study intended to add value and knowledge to private stakeholders from the non-governmental and private sector in the country. They were to learn on ways of effectively deploying these practices and innovate strategies which will become instrumental in bringing the much-needed increased profits for the farmers.

1.6.3 The Ministry of Agriculture and the National Irrigation Board of Kenya

This study was to assist the Ministry of Agriculture by providing vital information for the Rice Promotion Programme (RIPP) and their counterparts at the National Irrigation Board of Kenya (NIB). The study therefore, highlighted areas that need government intervention in policy development especially with the issue of enforcing the National Rice Development Strategy.

1.6.4 Academicians and Researchers

For academicians, the study findings filled the gaps in the area of advancing the rice sector and gave recommendations for further study to be done in the field. The study findings also can be used as a point of reference for other researchers, besides its value as library information material.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

The chapter reviews literature relating technology adoption with relation to increased incomes. The literature review attempted to answer the research objectives in relation to how these improved technologies can bring about an incremental change to the farmers' incomes. It also examined the extent at which these technologies can be adopted by farmers. The chapter comprises of theoretical review, empirical review, conceptual framework and ends with a chapter summary.

2.2 Theoretical Review of Literature

This study was anchored in Diffusion of innovation theory.

2.2.1 Diffusion of innovation theory

Diffusion theory was developed by Rogers in 1962 and stated that adoption is the extent of use of a new technology or innovation. Adoption takes place in long run equilibrium when the farmer has full information about the technology and its potential (Fageria, 2007). Adoption and diffusion are interrelated though different, in the sense adoption is when an individual makes use of an innovation, while diffusion means the spread of the innovation among a community or even globally (Fageria, 2007).

In this theory, adoption process is inseparable from the diffusion process. The adoption decision process describes five phases in adoption: knowledge, persuasion, decision, implementation, and lastly confirmation that individuals go through during their evaluation of an innovation, stage one is when an individual becomes aware of an innovation. The awareness of an innovation is influenced by personal characteristics, socioeconomic factors, and access to change agents like mass media (Chuchird, 2017). Stage two, persuasion, this is when an individual gain enough knowledge about the innovation's salient characteristics to make a personal judgment, the outcome of which is a favourable or unfavourable view of the innovation. Stage three, decision, this has an outcome of an individual's choosing to adopt or reject an innovation. Stage four, implementation, this is when an individual act on his or her decision. Finally, stage five, confirmation, this is when an individual reflects on his or her decision and implementation process and re-evaluates whether to continue or discontinue with the innovation adoption (Rogers, 1995).

In addition, Rogers (1995) classified the adopters into five categories of innovators; early adopters, early majority, late majority and laggards on the basis of the time taken to adopt the innovation and practically implement into their life style (Mati et al 2011).

Shemahonge, (2013) has explained the s- shaped adoption curve, which reveals that at the initial stage, the innovation diffused at slow pace. As more people adopt the innovation, it spreads quickly and ultimately the saturation point comes which indicates that everyone who need to adopt the innovation has adopted it.

It was therefore essential to study why various innovations are effective, whereas others are not. Various innovation has been noted by Rogers to define this mystery. They include observability, trial-ability, relative advantage, complexity, compatibility (Donkoh et al 2019). More observable, having high relative advantage, simple and compatible innovations tend to be adopted quickly. These factors offer a basic assessment list for technical project leaders to use when factoring innovative transformation and were also factors of concern to the researcher.

In this study, the significant components that influenced adoption of SRI and WSRC practices in Mwea rice farmers scheme were established and led to increased farmers' yields and income since farmers were adopting the ASIPs; Mwea rice farmers were at different levels of innovators/adoption (adopters and non-adopters) since the practices were still new and thus various interventions were proposed for full adoption of the technologies; the social economic characteristics of the farmers also determined the level of knowledge about ASIPs and persuasion to adopt of the said practices.

2.3 Empirical review of Extant of Literature

Kenya have had a potential of about 540,000 ha irrigable and 1 million hectares' rain-fed for rice production, with improved water harvesting, storage, underground water resource utilization and innovative management technologies, the current irrigation potential can be increased by a further 800,000 hectares to about 1.3 million hectares thus possibility of being self-sustainable (Ministry, Economic Review of Agriculture in Kenya, 2010). Good practices can be identified and examples of successful agricultural developments should be publicized, that is, the agricultural models that will lead to sustainable development must be prioritized, if Kenya was to be food secure. (Onyango, 2014).

It has been believed that the adoption of new agricultural technology, such as the high yielding varieties that kick-started the green revolution in Asia, could lead to significant increase in agricultural productivity in Africa and stimulate the transition from low productivity subsistence agriculture to a high productivity agro-industrial economy, (Onyeneke, 2017).

Adoption of improved agricultural technology has been crucial to increase agricultural productivity to meet food demand and ensure food security in developing countries. Productivity improving technologies has facilitated the growth of Agro-processing enterprise, thereby transforming the low productivity subsistence agriculture to a high productivity agro-industrial economy. However, many smallholders in developing countries have not been able to use improved crop practices and to realize the full potential of agricultural productivity. (Ghimire, Huang & Poudel, 2015)

To improve the output of rice, farmers have been advised to jointly adopt the identified improved production practices because they play a complementary role in increasing output and high incomes. Farmers have also been advised to join or form groups to be able to learn new techniques of production from their fellow farmers, and to stand the chance of contracting group loans and technologies which could increase their output, (Donkoh, Azumeh & Awumi, 2019).

2.3.1 The effect of SRI – (System rice intensification) Practices on farmers' yields and income

SRI was a mix of agricultural practices in rice production that produces substantially higher yields with planting fewer seedlings and the use of fewer inputs than the traditional rice production methods. It involved using different practices for seed and seedlings, soil, water and nutrient management. This system of rice intensification which originated from Madagascar has been successfully used in a number of countries notably India, Philippines and Mali (Uphoff et al., 2003). (ARC, 2007) SRI promoted establishment of rice seed nurseries as opposed to the traditional way of broadcasting seeds to establish a rice bed or field. A nursery was properly ploughed and mixed with organic manure and then the seeds were drilled in carefully made rows. SRI reduced usage of seeds from 25kgs per acre in broadcasting method to 15 kgs thus reduced costs of seeds used and thus improved profitability, (Kombe, 2012). The practice focused on agronomic factors for increasing yields but it did not consider the post- harvest practices that influenced the quality of the milled rice at factory level; adherence to set standards that oftenly are not followed by traders and also the transactions costs that affected the cost of the product at the consumer level hence affected his purchasing power. Such market factors influenced the production practices to be employed at the farm.

SRI emphasized on careful and quick transplantation of very young (8-12 days old) seedlings to minimize trauma to the roots. Transplanting only one seedling per hill (25cm X 25 cm) instead

of 3-4 together at wide spacing and in a square grid pattern to avoid root competition and encouraged greater root and canopy growth and enhanced productivity. The soil fertility was enhanced however, by use of compost from any available biomass, (Muhunyu, 2012).

Onyango, (2014) stated that SRI focused on keeping the soil moist but well drained and aerated with good structure and enough organic matter to support increased biological activity. It stressed on applying only minimum water during the vegetative growth period, flowering and grain filling stages. The fields were flooded and drained to save on labour and time. Weeding was done by use of simple, inexpensive mechanical push weeder which also aerated the soil as weeds were removed. The weeds were left in the soil to decompose hence retaining their nutrients.

Different studies suggested that there were large opportunities to improve rice management practices using SRI principles for better adaptability and profitability according to soil and varietal characteristics to obtain higher grain yield with less seed, and also less water, (Mati, 2011). However, the usage of one kind of intervention to improve may not have given the required outcome; seed quality, crop science and also satisfying consumer preferences are factors farmers needed to employ for sustainable results.

SRI increased the productivity of water, land and labour, with water savings of up to 50% because paddy fields was not kept continuously flooded. SRI was environmentally friendly in that water was available for other uses, there was greater biodiversity for unsaturated soil and zero production of methane (one of the major greenhouse gases contributing to global warming), thus sustainable agriculture. In addition, there was increased productivity per acreage hence small-scale farmers got high yields from their small land, (Muhunyu, 2012). Although the practice showed some effort on conserving the environment, there was no scientific evidence that the inputs used did not affect the environment thus contributing to global warming in the long run.

Mati, (2011) stated that SRI saved on the cost of seeds, pesticides and fertilizers since it did not require the purchase of new seeds or use of new high-yielding varieties and plant populations were reduced, organic materials gave better results and the plants were able to resist damage from pests and diseases. The practice may have reduced the production costs but not reduction of other costs i.e. transaction costs, handling costs etc. that affected the sales of rice production competitively.

ARC, (2007) stated that although SRI had been introduced in Mwea, there was little done on the agronomic package which included spacing, fertilizer/manure rates, number of weeding for ideal sustainable productivity. Spacing was one the major challenges since it was variety specific,

there was therefore need to evaluate the appropriate densities for optimal yield of the existing varieties. The combination of transplanting single seedlings per hill and following intermittent irrigation during the vegetative growth stage improved the crop Tillering leading to higher grain yield; these two crop management practices were key elements of SRI methodology, and their synergistic effects on root and shoot growth accounted for some of the higher yield reported when SRI practice was utilized. The studies did not depict the role of gender, age and education in adoption of SRI in Mwea scheme, although the formation of farmer co-operative had led to improvement of the rice production, (Kuria et al, 2003).

SRI seemed to improve on yields according to the study but it did not bring about the consumer tastes and preferences as factors that influenced purchase of the rice products and competitiveness thus affected the sales of the farmers.

Consequently, SRI adoption was however not fully adopted and this study was focussed on analysing the factors that influenced its adoption, and the specific components that led to increased rice farmers' yields and income/profitability.

2.3.2 The effect of WSRC- (Water Saving Rice Culture) on farmers' yields and income

JICA, (2016) stated that Water Saving Rice Culture (hereinafter WSRC) was an improvement of SRI practice but consisted of 5 components namely; manual levelling (after animal traction), healthy seedling (Sowing rate at 100g/m² and transplanting 3 weeks/ 21 days after sowing), Line planting with proper plant population (30x15cm, 22hills/m²), improved weeding (using rotary weeder) and intermittent irrigation (Rotation of 3 days flooding and 7 days without irrigation). (JICA, 2016). The 5 components were; Manual levelling – this involved land preparation using tractors or animal traction as opposed to manual land preparation. The activities involved at this level are disk ploughing, flooding, rotavation and levelling. This helped in better rooting, even growth and ease of water management thus high yields. Although mechanization was known to improve the efficiency of land operations, the practice did not consider other technologies that may be environmentally friendly e.g. precision agriculture, organic farming that improved sustainable agriculture.

Healthy seedling- entailed seed selection to have quality seed for sowing, after seed selection, the seeds were soaked in water for 24 hours then sowed in a seed nursery. The seedlings were nurtured for either 3 or 5 weeks and at 15kg/ acre seed rate. Mostly the seedlings were ready for transplanting when they were 15-20 cm tall, giving a high crop population leading to high yields. Line planting – involved establishing the inter-row and intra-row of the rice plant in the fields.

WSRC emphasized planting the seedlings at 30x15cm and allowed 3 seedlings per hill, line planting made it easier during weeding and also fertilizer application thus low cost of production. Improved weeding – conventionally weeding was impossible owing to the uneven crop population. WSRC made it easy for rotary push weeder in the fields thus it was very economical and efficient hence reducing on cost of production leading to improved profitability.

Intermittent irrigation- it emphasized a 3 days' wet field followed by 7 days of 'dry field' i.e. without having additional water in the paddy field. These was supposed to be repeated during the vegetative growth stage (45days), with this there was a lot of water saved for many farmers to utilize thus the water saving culture (WSRC). The practice saved over 20% of water used in the scheme thus sustained production, improved milled rice recovery and hence high returns at the both farmers and millers' perspectives, (JICA, 2016). According to JICA, (2016) the millers obtained better recoveries from the paddy however that was not the only parameter that influenced milled rice recovery; quality of the mill used and the moisture content of the paddy did. WSRC promoted use of natural factors of production, but with the uncertainty on climate change, the practice was not viable in case there was total rainfall failure; the study was focused on analyzing specific components of WSRC that led to increased yields and income.

Comparison of the rice farming practices

Table 2.3.1 Comparison of the rice farming practices

Traditional	SRI	WSRC
Continuous flooding	Intermittent flooding (3 days flooding, 7 days without flooding)	Intermittent flooding (3 days flooding, 7 days without flooding)
Broadcasting	Line planting 25cm X 25 cm	Line planting 30cm X 15 cm
No manuring	Manuring with organic matter	Manuring with organic matter and splits of inorganic fertilizer
Manual and chemical Weeding	Rotary push weeder used	Rotary push weeder used
Un even Hills	Single seedling/hill	2/3 seedlings/hill
Manual land preparation	Intensive mechanical levelling	Intensive mechanical levelling
Hand Harvesting	Mechanical harvesting	Mechanical harvesting
Seeds sowed after soaking in water for 24hours	Seedlings transplanted in 14 days	Seedlings transplanted in 21 days

Source (Ministry of Agriculture, 2017)

2.3.3 The effect of Social Economic characteristics on rice farmers' yields and income

Socioeconomic characteristics of the farmers was significantly associated with the stated adoption of the various sustainable intensification practices in farming, in view of the fact that socioeconomic factors such as age, gender, farm income, cooperative membership, household size, level of education, farm size and number of contacts with extension workers was seemingly associated with high adoption of any given agricultural practices and ultimately high yields. Younger, elites and male farmers seemed to adopt practices more easily as compared to old,

illiterate and female farmers. High yields was mostly associated with high returns however other factors like market accessibility and prices come into play (Rana, 2014). Other studies had placed male farmers as high adopters but women empowerment globally had placed female farmers in high positions in society, they own land and make adoption decisions in their farms.

Pandey, (2010) argued that research and policies affected scalability of given practices in agriculture. Constant research approaches on rice practices gave birth to rice production in conjunction with aquaculture thus improved food security and incomes. Land fragmentation policy in Philippines was affected and focused on production per unit area, these boosted production of rice per unit of land and improved returns, however the study did not analyze the effect of aggregation of farmers produce in farmers' organizations as a factor that speed adoption of a practice out of group psychology.

Shemahonge, (2013) stated that extension services influenced adoption of improved rice farming practices in a positive way leading to high yields in crops and animal, he added that the results from a neighbouring farmer influenced another farmer in adopting a given practice by giving confidence of adopting them therefore improved on production. Its true extension services caused dissemination of practices, however, its compatibility, accessibility and cost hindered its adoption in a given area.

Alemu, (2011) emphasized that access to market and credit gave a farmer incentive in expanding ones production and also the speed in adopting a given technology. Contrary to other studies, Alemu, (2011) refuted that education influenced adoption of technology, he argued education only worked on disseminating technical information of production but not in adopting any practice.

Mati, (2011) argued that younger farmers with higher access to credit and at the same time literate tended to adopt agricultural practices that led to high yields in rice farming. However, the study did not analyze the influence of other factors like gender, household size, farm size and cooperative membership in adoption of agricultural practices in the scheme; many young people did not access land and thus cannot make a decision on adoption of a practice.

The gender and gender roles in most African countries affected agricultural production in a negative way especially on land access and ownership, Omondi, (2013). Omondi, (2013) showed that land ownership due to gender, bars out women and youth in producing rice. In addition, lack of farming capital made most women and youth to forfeit rice production thus search for other income generating activities rather than farming. Failure to access land documents made most upcoming farmers miss out credit from financial institutions since there didn't produce

collateral, these affected negatively rice production in Ahero scheme resulting to subsistence and traditional farming, (Onyango, 2014). Many studies showed that women and youth did not have access to land and thus made no adoption decisions, however, there existed no study showing how their knowledge contributed to their male parents in making such decisions since they advised them as a family.

There existed limited study on how age, gender and education affected adoption of ASIPs in Mwea rice farming scheme since 75% of the farmers were young farmers in the region, and these study wished to address these factors and their influence on farmers' yields and income in Mwea.

2.3.4 Rice Farmers yields and income

Rice production in the developed nations like USA, South Korea and Japan was approximately 12-15 tonnes per acre. (Ghimire. Raju, 2015). In Africa the highest yield per acre was 8 tonnes per acre in countries like Senegal. In East Africa, Kenya recorded the highest with an average of 5.5 tonnes per acre, (GRiSP, 2013). Consumption of rice was growing faster than that of any other food commodity in Africa, because it had become a convenience food for the growing urban populations. Imports of rice (close to 10 million tonnes (Mt) per year), (ARC, 2007).

Kuria et al, (2003) stated that the major constraints on rice production in the region were: high cost of production and low prices offered to the farmers. The cost of production in the region was recorded to be the highest in the East African region amounting to Ksh 70 per kg compared to Ksh 35 in Pakistan which was even subsidized by the government to as low as Ksh 25. These kind of interventions by Pakistan's government made it easier for their farmers to produce cheaply and thus had a competitive advantage among other rice growers in the world.

The cost of inputs such as fertilizers and chemicals was increasing every day and the ordinary rice farmer had to bear with it to produce one kg of rice in the scheme. In addition, the fee charged on water provided by the water authorities was also high and yet was not enough to all farmers leading to crop failures thus affecting the rice production and targets in the region, (Onyango, 2014).

Consequently, the rice was sold at an average of Ksh 150 per kg compared to the imported rice at Ksh 100. The hard-produced rice suffered marketing challenges in spite of low production and high consumption in the region, (NIB, 2019). These factors of production affecting the rice farmer in the region definitely discouraged the farmer from engaging in rice farming as opposed to the farmers in the developed nations where they were encouraged to produce.

Kuria, et al (2003) stated that in Pakistan the average income of ordinary rice farmer per acre was Ksh 365,000, in Japan the farmer pockets Ksh 370,000 while in South Korea its Ksh

376,000. In Africa on the other hand the average income was Ksh per acre is Ksh 125,000 in Mali, Ksh 128,000 in Nigeria and Ksh 135,000 in Senegal. In East Africa Uganda had Ksh 96,000, Ksh 112,000 in Tanzania and Ksh 123,000 in Kenya. Mwea farmer had the highest income of Ksh 120,000 per acre compared to other schemes in the country.

The cost of production of rice in Mwea scheme was quite high owing to the high prices of inputs and other factors. The many inefficiencies at the farm level due to either low or no adoption of improved sustainable practices made rice production very unprofitable with low yields. High yields are associated with high returns even though other factors play a role in establishing the margins gained by the farmer. The gross income accrued from the sale of rice in Mwea had little impact to the living standards of the farmers since the yields were low and or other factors. The housing, food and education of rice farmer was in want due to the low income from the rice farming compared to other farmers in developed nations. (Ministry, Economic Review of Agriculture in Kenya, 2010).

The credit facilities given to rice farmers were at highest rates and thus the farmer had no hope of increasing volumes of scale due to constrained capital. There was no affordable crop insurance against crop failures hence the farmers in the scheme stood at high risks of surviving in case a catastrophe struck, (Olembo, 2010). Rice farmers in developed countries enjoyed high prices set by the government who happened to be the highest offtake of their produce. These assured steady incomes for such farmers as opposed to Mwea scheme farmers. It was amazing that the rice farmers in Mwea had to search for market for their produce and thus were left at the mercies of the brokers, (Omondi, 2013).

Many studies had shown that the major contributor to low rice income for the many farmers is high cost of production, low adoption of improved rice production practices and uncontrolled imports. These study wished to analyse what factors influenced rice farmers yields and income in Mwea Irrigation scheme and if adoption of sustainable intensification practices affected farmers' yields and income.

2.4 Summary of Literature Review

The common improved rice practices stated as being adopted by farmers include improved rice varieties, fertilizer application, agrochemicals and optimum seed rate in planting, (ARC, 2007).

FAO (2008) identified traditional rice-cropping problems which included the use of low quality, mixed varieties seed leading to degradation over time in quality, high cost of fertilizer and difficulty in procuring fertilizer in the appropriate amount at the appropriate time, low level of knowledge and training, lack of irrigation facilities, lack of storage facilities, poor pests and

disease management, ineffective farm implements, lack of access to institutional and infrastructural support and low farm mechanization. However, according to (JICA,2016), rice production can generally be divided into seed selection, land preparation, timely planting, crop establishment, water management, nutrient management, crop health, harvesting and post harvesting operations. (Onyeneke, 2017)

Adoption of the newly released rice variety named IR522 developed by KARI Kenya in partnership with IRRI and that other varieties that were high yielding and application of available practices in rice growing areas had been low leading to low yields in most areas. Some of the reasons posed are inaccessibility, lack of information of such technologies among the farmers. (Onyango, 2014).

An irrigation scheme was a systematic approach to managing water in the farmland whereby the water is provided to and channelled away from the farmland, and also included the conservation of water for dry seasons and ecological maintenance. Nevertheless, there was evidence of lack of adoption of irrigation practices, giving rise to ineffective water resources management, perceived inequality in the water allocation, and low economic well-being. (Chuchird Ratchaneewan, 2017).

Evidence was mounting that flooded rice soils are not resilient to intensification pressures, and that the productivity made possible by current practices may not be sustainable. Nevertheless, irrigated systems must produce even larger sustainable yields economically if future populations are to be fed. (Ministry of Agriculture, 2017).

Irrigation was important for the crop productivity improvement. Other variables that affected rice yield are age, gender, education, extension services, access to credit, market participation, off-farm income, use of tractor, fertilizer application rate and farm labour. (Melaine, 2017). Introduction of a policy on traceability by using geospatial data to map every aspect of the rice production in Kenya (e.g. soil composition, fertilizer, seeds, weather patterns, growth patterns, settlement details, degree of mechanization) was a way of incentivizing specific positive behaviour by value chain actors through market mechanisms e.g. targeted marketing of high quality produce, import substitution to meet domestic demand using various policy instruments (IRRI, 2013).

There existed a major gap between rice production and national consumption in Kenya thus the country imported a lot of rice to bridge the deficit yet there was untapped potential in irrigable land for rice production. The farmer on the other hand accrued minimum benefits associated to rice farming since there were low production thus low returns. These untapped potential can only be tapped by adopting ASIPs by all rice farmers in the country (NRDS, 2019).

2.5 Summary of Literature Gaps

Author	Research Focus	Major findings	Knowledge gaps
Rana, (2014)	Effect of planting methods on the yields and yield attributes of short duration Aman rice. American Journal of Plants Sciences. 251-255	Socioeconomic characteristics of the farmers are significantly associated with the stated adoption of the various improved rice production technologies in farming	The study did not infer on farmers groupings, household size and access to credit as a factor in technologies or agricultural practices adoption.
Onyeneke, (2017)	Determinants of Adoption of Improved Technologies in Rice Production in Imo State Nigeria. African Journal of Agricultural research.	Farmers should receive more training and knowledge about improved rice technologies through steady flow of information by the extension agents, rice processing industries should be established by private organizations to encourage commercial farming to support adoption of more improved rice technologies to boost their production and productivity	The study did not consider the role of the public sector in ASIPs adoption among rice farmers.
Onyango, (2014).	Exploring Options for Improving Rice Production to Reduce hunger and Poverty in	Good practices should be identified and examples of successful agricultural	The study missed on various modern agricultural technologies of disseminating agricultural

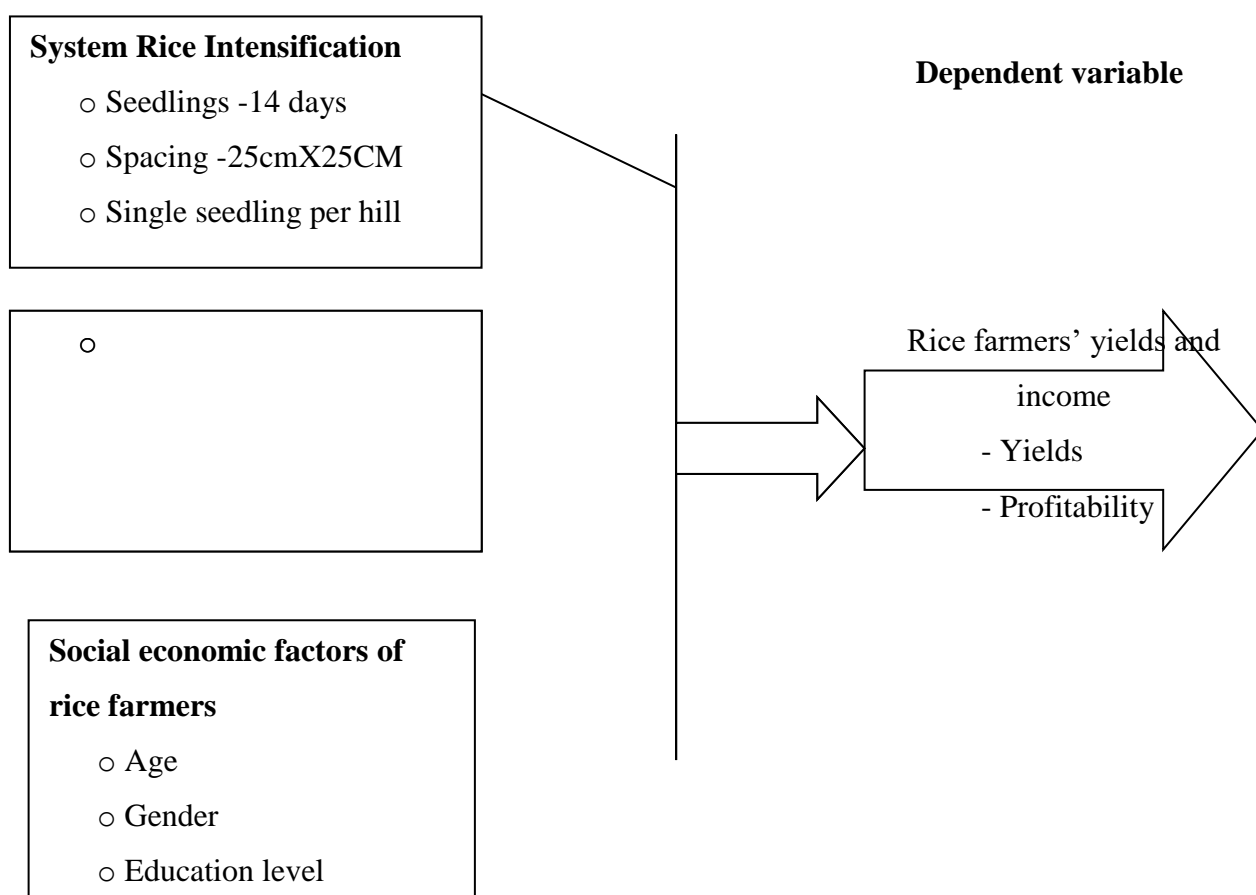
	Kenya. World Environment.	development should be publicized, that is, the agricultural models that will lead to sustainable development must be prioritized, if Kenya is to be food secure	practices information to enhance adoption.
Onyeneke, (2017)	Determinants of Adoption of Improved Technologies in Rice Production in Imo State Nigeria. African Journal of Agricultural research.	It is believed that the adoption of new agricultural technology, such as the high yielding varieties that kick-started the green revolution in Asia, could lead to significant increases in agricultural productivity in Africa and stimulate the transition from low productivity subsistence agriculture to a high productivity agro-industrial economy.	The study did not consider the factors that influenced accessibility and acceptability of such practices to the farmers i.e. cost and usability, scalability, replicability etc.
Ghimire, (2015).	Adoption Intensity of Agricultural Technologies: Empirical Evidence from Smallholder Maize Farmers in Nepal. International Journal of Agriculture Innovations and Research.	Adoption of improved agricultural technology is crucial to increase agricultural productivity to meet food demand and ensure food security in developing countries.	The study focussed on maize and not rice farming as a means in enforcing food security and also the market factors that can influence innovations and adoption of practices.

Donkoh Samuel Arkoh, (2019).	Adoption of Improved Agricultural Technologies among Rice Farmers in Ghana. Ghana Journal of Development Studies.	To improve the output of rice, farmers are advised to jointly adopt the identified improved production technologies because they play a complementary role in increasing output and high incomes.	The study did not depict the benefits of adopting technologies as a factor in influencing adoption and also focused on single technologies instead of mixed technologies.
JICA, (2016).	The Tokyo International Conference on African Development (TICAD). Nairobi: JICA.	Rice production can generally be divided into seed selection, land preparation, timely planting, crop establishment, water management, nutrient management, crop health, harvesting and post harvesting operations.	The study did not incorporate the farmers groupings as a factor contributing adoption of technologies
Chuchird, (2017).	Influencing Factors of the Adoption of Agricultural Irrigation Technologies' and the Economic Returns: A case study in Chaiyaphum Province. MDPI - sustainability.	There is evidence of the lack of adoption of irrigation technology, giving rise to ineffective water resources management, perceived inequality in the water allocation, and low economic well-being.	The study did not investigate upland rice production, it only focused on irrigable rice production.
Melaine, (2017).	Effect of Adoption of Irrigation on Rice Yield in the Municipality of	Other variables that affect rice yield are education, extension	The study did not consider use of HYV as a factor in increasing yields or as a

	Malanville, Benin. African Development Review.	services, access to credit, market participation, off-farm income, use of tractor, fertilizer application rate and farm labour.	technology.
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2.6 Conceptual framework

Independent variables



2.6.1 Operationalizing variables

Agricultural practices and social-economic factors whose occurrence affected rice farmers' yields and income were conceptualized for this study as SRI, WSRC and social-economic factors of the farmers. The level of measurement and the method of analysis for each of these variables is summarized in Table 2.3.2

Table 2.3.2 Operationalization of Variables

Independent variable	Measurement	Measurement scale	Expected outcome
Social - economic factors			
Age	No. of years since birth	Ratio	+/-
Gender	Male/female	Nominal	+/-
Education level	Years respondent has in formal education	Ratio	+/-
SRI practices			
Seedlings age-14 days	Days of the seedlings	Ratio	+
Line planting – 25cmX25cm	Length of the rows and intra rows	Ratio	+
Single seedling per hill	Number of seedlings per hill	Ratio	+
WSRC practices			
Seedling age – 21days	Days of the seedlings	Ratio	+
Line planting – 30cmX15cm	Length of the rows and intra rows	Ratio	+

2/3 seedlings per hill	Number of seedlings per hill	Ratio	+
Dependent variable			
Farmers yields	No. of bags per production area	Ratio	+/-
Farmers profitability	Gross margin in shillings	Ratio	+/-

Source researcher (2020)

2.7 Chapter Summary

The chapter reviewed the relevant literature available on the subject of the importance of adopting ASIPs in rice production within the perimeters of the research questions guiding the study; (i) what was the effect of adopting SRI practices in rice farmers' income in Mwea rice scheme? (ii) What was the effect of adopting WSRC practices in rice farmers' income in Mwea rice scheme? (iii) What was the relationship between socio-economic characteristics of the rice farmers and adoption of ASIPs in rice farmers' income in Mwea scheme?

This study made deliberate efforts at gaining in depth appreciation of the benefits of ASIPs and innovative farming practices and their effects on farmers' yields and income. The next chapter dealt with the research methodology. It focused on the research design that was employed, the sample and sampling technique and how the data was collected, research procedure and data analysis.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Introduction

This chapter discusses the research methodology that was utilized in this study. It focussed on the choice of the research design and why it was favoured over other optional designs. The chapter also discusses the population, sample and sampling techniques employed. The chapter includes the data collection methods, data analysis and data presentation methods in the study.

3.2 Research Philosophy

Research philosophy referred to a system of beliefs and assumptions about the development of knowledge, it dealt with the source, nature and development of knowledge, in simple terms, a research philosophy was belief about the ways in which data about a phenomenon should be collected, analysed and used formulating once beliefs and assumptions, (Burrell and Morgan 1979). This study used Epistemology philosophical assumption which concerns assumptions about knowledge, what constitutes acceptable, valid and legitimate knowledge, and how we can communicate knowledge to others (Burrell and Morgan 1979). Whereas ontology may initially seem rather abstract, the relevance of epistemology was more obvious. The multidisciplinary context of business and management meant that different types of knowledge – ranging from numerical data to textual and visual data, from facts to interpretations, and including narratives, stories and even fictional accounts was all considered legitimate. Consequently, different business and management researchers adopted different epistemologies in their research, including projects based on archival research and autobiographical accounts (Martí and Fernández 2013), narratives (Gabriel et al. 2013) and fictional literature (De Cock and Land 2006).

Since there were many epistemologies leading to various methodologies, this study used pragmatism philosophy which asserted that concepts were only relevant where they supported action (Kelemen and Rumens 2008). Pragmatism originated in the late-nineteenth–early twentieth- century in USA in the work of philosophers Charles Pierce, William James and John Dewey. It strived to reconcile both objectivism and subjectivism, facts and values, accurate and rigorous knowledge and different contextualised. It does this by considering theories, concepts, ideas, hypotheses and research findings not in an abstract form, but in terms of the roles they play as instruments of thought and action, and in terms of their practical consequences in specific. For a pragmatist, research starts with a problem, and aims to contribute practical solutions that inform future practice. As pragmatism is more interested in practical outcomes than abstract distinctions, their research may have considerable variation in terms of how

‘objectivist’ or ‘subjectivist’ it turns out to be. Pragmatists recognise that there are many different ways of interpreting the world and undertaking research, that no single point of view can ever give the entire picture and that there may be multiple realities

3.3 Research Design

Research design is the contextual thinking process behind a given research problem. Research design carries along research questions, propositions, and units of analysis, a logical link between data and propositions and criteria for interpreting findings (Mugenda and Mugenda, 1999).

The nature of the study called for a quantitative methodology using a survey design and analysing data using descriptive statistical methodologies so it had an accurate profile of adoption rice practices in Mwea scheme collecting quantitative data which was mainly numerical and discrete. Then a structured questionnaire was used consisting of closed and open-ended questions issued using stratified sampling (adopters and non-adopters for the SRI and WSRC) to the farmers in interviews and focus groups

3.3.1 Study area

The study took place in Kirinyaga County approximately 100 km North East of Nairobi, in Mwea West and East Sub-counties. The two counties host the largest irrigation scheme in East Africa with approximate 33,000 acres under irrigable rice, (NIB, 2019).

3.4 Target Population

A population refers to the total collection of elements about which one wishes to make inferences to (Mugenda & Mugenda, 1999). For this study, the target population comprised of rice farmers who were members of the Mwea Rice Growers Cooperative. According to Mwea Rice Growers Cooperative there are 3,200 active farmers. It was from this population (3,200) that the researcher strived to get an accessible population that assumed generalization from it (Mugenda and Mugenda, 1999). The unit/strata under study was therefore 400 farmers who had either adopted or not adopted the ASIPs.

Table 2.3: Target Population

Designation	Population	Sample	Procedure	Data collection tool
Rice farmers	3,200	400	Stratified sampling (adopters and non-adopters)	Structured Questionnaire
TOTAL	3,200	400		

Source Researcher 2020

3.5 Sampling Frame

A sampling frame is the list of elements from which the sample was drawn, Mugenda and Mugenda (1999). The sampling frame for this study was a list of farmers from Mwea Rice Growers Cooperative totalling to 400 out of the 3,200 farmers either adopting or not adopting the ASIPs in Mwea scheme from Mwea East and West Sub-counties.

3.6 Sample and Sampling Technique

A stratified sampling method was used in this study; as both adopter and non-adopters of the practices from rice farmers Cooperative were involved in the research. The researcher relied on the Cooperative's membership office to obtain access to the sample of farmers who were active members. Therefore, the researcher requested all the persons eligible for the study to participate , According to Bryman (2016) acceptable sample has less than 10% error and with a confidence level of more than 95% for greater accuracy, in getting the minimum sample size, a sampling error of 5 % was used.

The formula is as shown:

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

In which: N=population size- 3200 e= sampling error at 0.05 n=sample size

Therefore:

$$\begin{aligned} n &= \frac{3200}{1+3200(0.05)^2} \\ &= 399.87 \end{aligned}$$

Hence 400 respondents were the lowest acceptable number to achieve 5% sampling error at 95% confidence level.

3.7 Data Collection Method

Quantitative data was collected from primary source using structured questionnaires. Bryman, (2016). Novak, (2014) explained that questionnaires was important instrument for research; a tool for data collection. The use of questionnaires presented the information required from the respondents in an easy way through closed ended and open-ended questions.

3.8 Data Collection Procedure

The first section of the questionnaire determined the social economic factors of the farmers affecting adoption of the practices, the second section determined state of SRI practices within the rice scheme. The third section explored how WSRC was adopted and its impact on farmers' yields and income. To increase the response rate, the researcher carried out pilot questionnaire testing to increase understanding of the questions by the farmers, in addition, the researcher involved the farmers' co-operative membership to administer the questionnaire.

3.9 Data Processing and Analysis

The quantitative data was collected from primary and secondary sources and quantitative methods was used for data analysis. STATA was used to conduct data analysis and the regression analysis was applied for empirical model estimation. Specifically, the Ordinary Least Squares Method (OLS) was applied for empirical model regression. The choice of the model was informed by the assumptions of the OLS model. First was the assumption of linearity. This assumption asserts that the dependent variable is a linear function of independent variables. The second assumption was that the error term of the model is normally distributed with the expected mean of 0 and variance of δ^2 ($\varepsilon \sim 0, \delta^2$). The assumption here was that the expected value of the mean of the error terms of OLS regression should be zero given the values of independent variables. In other words, the distribution of error terms has zero mean and does not depend on the independent variables. Thus, there must be no relationship between the independent variables and the error term of the model.

Further, the OLS model assumed that the variance error term was the same across all values of the independent variables (homoscedasticity). This assumption asserts that the error terms in the regression should all have the same variance. In case of violation of this assumption, then the linear regression model has heteroscedastic errors and likely to give incorrect estimates. In addition, the model assumed that there was no multi-collinearity (or perfect collinearity) in cases of multiple regression model. This assumption implies that there should be no linear relationship between the independent variables in the model. The important implication of this assumption of OLS regression is that there should be sufficient variation in the independent variables. This is

because the more the variability in the independent variables the better as it makes the OLS estimates statistically significant in reference to their effect on the dependent variable.

Lastly, is the assumption of no auto-correlation. This OLS assumption of no auto-correlation implies that the error terms of different observations should not be correlated with each other. This assumption means that the error terms should be Independent and Identically Distributed (iid). It is also notable that while the choice of the OLS model for empirical estimation was informed by the model assumptions, its choice was informed by the fact that it was the basic econometric model upon which all other econometric models are built from.

Within the OLS model, the independent variables were the farming practices adopted by the farmers. The dependent variable was the farmers' income and output implying that two OLS models were estimated one for the rice output/yield and the other for the change in farmer's income levels. The dependent variable is denoted by Y. The general representation of the model is given as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_K X_K + \varepsilon_i$$

$$Y = X_i \beta + \varepsilon_i$$

Where: Y represents increase in farmer's income levels and output level.

X_i represents the various farming strategies adopted by the farmers

β_0 and β_{1-k} are estimable parameters

ε is the error term.

As per the nature of the study two specific OLS empirical models was estimated as per the different agricultural sustainable intensification practices

$$Yield_i = \beta_0 + \beta_1 Age_i + \beta_1 Gender_i + \beta_1 Edu_i + \beta_1 SAI4_i + \beta_1 LS25cm_i + \beta_1 SShill_i + \beta_1 SA21days_i + \beta_1 LP30cm_i + \beta_1 2/3Shill_i + \varepsilon_i \dots \dots \dots (3.1)$$

$$Income_i = \beta_0 + \beta_1 Age_i + \beta_1 Gender_i + \beta_1 Edu_i + \beta_1 SAI4_i + \beta_1 LS25cm_i + \beta_1 SShill_i + \beta_1 SA21days_i + \beta_1 LP30cm_i + \beta_1 2/3Shill_i + \varepsilon_i \dots \dots \dots (3.2)$$

Where:

Income is the farmers' income

Yields is the farmers' rice yield

Age is the age of the farmer in years

- Gender is the gender of the farmer
- Edu is the education level attained by the farmer
- SA14 is the seedling age – 14 days (SRI practice)
- LS25cm is the line spacing – 25cmX25cm (SRI practice)
- SShill is the single seedling/hill (SRI practice)
- SA21 is the seedling age – 21 days (WSRC practice)
- LP30cm is the line planting – 30cmX15cm (WSRC practice)
- 2/3 Shill is the 2/3 seedlings/ hill (WSRC practice)
- ϵ is the error term of the model
- β_0 is the constant of regression model
- β (s) are the coefficients of the independent variables

3.10 Research quality

3.10.1 Instrument Piloting

Piloting for questionnaires was administered to a random sample of 20 respondents selected before the actual research to ensure that respondents did not misinterpret the questions and that they followed the instructions.

3.10.2 Instrument Validity

The research used Content Valid Index (CVI) to check consistency, legitimacy and significance. These were relevant items to the objectives over total number of items.

$$\frac{\text{Relevant Items}}{\text{Total number of items}} = \text{CVI}$$

According to Novak (2016), items in the research instrument are valid and acceptable if the CVI is 0.7 and above. (Connelly, 2014)

3.10.3 Instruments Reliability

Reliability is a measure of the degree to which the research instruments present consistency of results even after several trials (Mugenda & Mugenda, 2003). To assess the internal consistency, Cronbach's alpha coefficient was used. According to Novak (2016), items in the research instrument are reliable if the correlation is 0.7 and above.

3.12 Measurement of the variables

Within the study the variable of the model were defined and measured as follows:

Table 3.1: Definition and measurement of variables

Variable	Definition	Measurement
Gender	Refers to the gender / sex of the farmer	1 if Male, 0 otherwise.
21 days Seedlings	Refers to whether the farmer adopt planting of 21 days seedling practice	1 if adopted planting seedlings at 21 days, 0 otherwise.
14 days Seedlings	Refers to whether the farmer adopt planting of 14 days seedling practice	1 if adopted planting seedlings at 14 days, 0 otherwise.
Spacing 25cm X 25cm	Refers to whether the farmer adopt planting of 25cm by 25cm planting spacing practice	1 if adopted 25cm X 25cm spacing 0 otherwise.
Single seedling per hill	Refers to whether the farmer adopts planting of single seedling per hill practice	1 if adopted Single seedling per hill 0 otherwise.
2/3 seedling per hill	Refers to whether the farmer adopts planting of 2 or 3 seedling per hill	1 if adopted 2/3 seedling per hill 0 otherwise.
Spacing 30cm X 15cm	Refers to whether the farmer adopts 30cm by 30cm planting spacing practice	1 if adopted 30cm X 35cm spacing 0 otherwise.
Yield increase	Refers to whether the farmer has experienced increase in rice yield as a result of adopting sustainable intensification practices	1 if yield has increased 0 otherwise.
Income increase	Refers to whether the farmer has experienced increase in incomes as a result of adopting sustainable intensification practices	1 if income has increased 0 otherwise.
Age	Refers to the age of the farmer	Farmer's age in years
Education level	Refers to the highest education level attained by the farmer	Farmer's years spend in school

3.12 Ethical Considerations

According to Bryman (2016), ethics is defined as fundamental principles and morals that guide human conduct. Connelly (2014) affirmed that ethical considerations was important for a research. To be ethical the researcher upheld ethical principles and standards in ensuring that the

collected data was treated with utmost confidentiality to observe the ethical rules by striving to avoid any harm to respondents. Further the researcher sought for a letter of introduction from the Strathmore Business School to accompany the questionnaire administered to respondents before distributing the questionnaires

In addition, the researcher sought permission from the relevant authorities including Strathmore Review and Ethics Committee, NACOSTI, County Director of Education and MRGM.

3.12 Chapter Summary

This chapter described the process and procedures to be followed in locating and collecting the data relevant to the study and how the data was organized, analysed, summarized and presented. The next chapter was to present the findings and analysis of the study.

CHAPTER FOUR

DATA ANALYSIS, INTERPRETATION AND DISCUSSION

4.1 Introduction

This chapter details data analysis, interpretation and discussion of the study. Specifically, the chapter entails the summary statistics of the model variables, the OLS regression model estimations and the respective correlation analysis effects results with their respective interpretations and discussions.

4.2 Descriptive Summary statistics

The summary of descriptive statistics is shown in Table 4.1. Out the 400 rice farmers target sample for the study, only 339 farmers gave full responses to the questionnaire translating to the response rate of 84.75 percent. From the sample analysis, the descriptive statistics on social economic factors showed that 56.05 percent of the farmers were male with their counterparts accounted for 43.95 percent. The average age of the respondent was 47 years with the youngest farmer being 21 years and oldest 93 years old. The average years spent in school by the respondent were nine years with 16 years being the highest number of years spend on education.

Descriptive statistics results on agricultural practices indicated that 43.95 percent of the farmers adopted transplanting seedlings at 21 days after sowing while 34.81 percent adopted transplanting 14 days old seedlings. Spacing of 25 cm by 25 cm was practiced by 43.07 percent of the farmers while 37.76 percent of the respondents adopted seedlings spacing of 30cm by 35cm. On number of seedlings per hill, 33.04 percent of the farmers planted a single seedling per hill with 39.53 percent of the respondents practiced 2 to 3 seedlings per hill.

Results showed that the average paddy yields per acre realised by the respondents was 2,597 kg ranging from 1000 to 5400 kg. The average farmers' incomes revealed that gross income level was Ksh 168,021 ranging from 50,000 to 306,000 per acre. Of the farmers interviewed, 40.41 percent reported having experienced increase in the yields while 15.34 percent reported an increase in their incomes from rice farming.

Table 4.1 Descriptive statistics

Variable	Measurement	Obs	Mean	Std. Dev.	Min	Max
Gender	1 if Male, 0 otherwise.	339	56.05	0.497	0	1
Age	Farmer's age in years	339	47	12.371	21	93
Education level	Farmer's years spend in school	339	9	3.419	0	16
21 days Seedlings	1 if adopted planting seedlings at 21 days, 0 otherwise.	339	43.95	0.497	0	1
14 days Seedlings	1 if adopted planting seedlings at 14 days, 0 otherwise.	339	34.81	0.4771	0	1
Spacing 25cm X 25cm	1 if adopted 25cm X 25cm spacing 0 otherwise.	339	43.07	0.4959	0	1
Spacing 30cm X 15cm	1 if adopted 30cm X 35cm spacing 0 otherwise.	339	37.76	0.4854	0	1
Single seedling per hill	1 if adopted Single seedling per hill 0 otherwise.	339	33.04	0.471	0	1
2/3 seedling per hill	1 if adopted 2/3 seedling per hill 0 otherwise.	339	39.53	0.4896	0	1
Yields (kgs/acre)	Total yield per acre	339	2597.097	610.5	1,000	5,400
Income levels (ksh)	Total income from rice sales	339	168,021.40	47,596.87	50,000	306,000
Yield increase	1 if yield has increased 0 otherwise.	339	40.41	0.4914	0	1
Income increase	1 if income has increased 0 otherwise.	339	15.34	0.3609	0	1

4.4: OLS Model - effect of agricultural sustainable intensification practices in rice farming on farmers' yields – Objective 1

Results of correlations between paddy yield and components of System of Rice Intensification and Water Saving Rice Culture are presented in Table 4.2. The correlation between paddy yield and components of WSRC were moderate, positive and highly significant ($P < 0.01$) for transplanting 21 day old seedlings ($r = 0.69$), moderate, negative and highly significant for 30 x 15 cm spacing and non-significant for transplanting 2/3 seedlings per hill. The correlation between paddy yield and components of SRI were positive, weak and highly significant for 25 x 25 spacing ($r = 0.18$) and transplanting single seedling ($r = 0.12$), and positive, weak and significant ($P < 0.05$) for transplanting 14 days old seedlings.

Table 4.2 Correlation Analysis

	Yield	14 days seedlings	21 days seedlings	Spacing 25 x 25	Spacing 30 x15	Single seed rate	Seedling 2/3 seeds
Yield	1.0000						
14 days seedlings	0.0954 (0.0132)	1.0000					
21 days seedlings	0.6868 (0.0000)	0.1778 (0.0000)	1.000				
Spacing 25 x 25 cm	0.1777 (0.0031)	0.1900 (0.0000)	-0.1584 (0.0000)	1.0000			
Spacing 30 x15 cm	-0.3814 (0.0000)	0.1176 (0.0000)	-0.3192 (0.0830)	0.2674 (0.7200)	1.000		
Single seed rate	0.1188 (0.0000)	0.0179 (0.0580)	0.0740 (0.0610)	0.0093 (0.0690)	0.5383 (0.0900)	1.0000	
Seedling 2/3 seeds	0.3578 (0.0570)	0.0551 (0.0286)	0.2614 (0.0656)	0.4668 (0.7200)	0.3746 (0.0462)	0.1357 (0.4090)	1.0000

The OLS regression model results for the effect of the farming practice on the rice yield are presented in Table 4.3. From the findings of this study, the OLS model results indicated that components of system of rice intensification as represented by transplanting 14 days old seedlings, spacing of 25 x 25 cm and transplanting a single seedling per hill had an effect on rice yield. Adoption of 25 x 25 cm spacing had a positive and significant ($p < 0.05$) effects on rice yield recording an increase of 1.495 percent holding other factors constant. Adoption of transplanting 14 days old seedlings and using a single seedling recorded an increase of 0.424 percent and 1.886 percent respectively

Table 4.3 OLS regression for yield increase

Yields	Coef.	St.err.	t-value	p-value	[95% Conf	Interval]	Sig
14 days seedlings	0.424	0.778	0.54	0.709	-112.811	165.658	
Spacing 25 x 25	1.495	1.522	0.98	0.015	31.666	297.324	**
Single seed rate	1.886	1.846	1.02	0.353	-208.221	74.448	
21 days seedlings	0.355	0.374	0.95	0.012	78.212	630.499	**
Spacing 30 x15	-1.130	1.090	-1.04	0.933	-248.338	228.078	
Seedling 2/3 seeds	2.692	0.260	2.14	0.003	-455.071	41.687	***
Age of farmer	0.416	2.760	0.15	0.018	-5.014	5.846	**
Education level	1.969	1.257	1.57	0.244	-8.209	32.147	
Gender (male)	1.764	1.503	1.17	0.017	28.971	294.557	**
Constant	2.366	1.347	1.76	0.000	1883.784	2616.947	***
R-squared		0.674	Number of obs		339.000		
F-test		2.904	Prob > F		0.003		
Adj R-squared		0.548					

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Source: Author's computation (2019).

However, the effects of transplanting 14 days old seedlings and using a single seed per hill on rice yield were positive but non-significant.

Regarding the Water Saving Rice Culture, the OLS model results showed that transplanting 21 days old seedlings, spacing of 30 x 15 cm and transplanting 2/3 seedlings per hill had effects on rice yield. Of the three components transplanting 2/3 seedlings per hill had a positive and highly significant ($p < 0.01$) effect on rice yield recording an increase in rice yield of 2.692 percent holding other factors constant. This was followed by transplanting 21 days old seedlings that had a positive and significant ($p < 0.05$) effects on rice yield. The component of 30 x 15 cm spacing had a negative but non-significant effect on rice yields.

On social economic factors farmers age had a positive and highly significant effects on rice yields indicating that the rice yields increase with the increase in farmer's age. This could be possibly explained by the increase in farmer's experience with age. Regarding gender, male farmers we found to likely have more yield compared to their counterpart female farmers

The additional model information asserts that 67.4 percent (Coefficient of determination R^2) of the total changes in the rice yield are accounted for by the changes in the System Rice Intensification and the Water Saving Rice Culture adopted by the farmers and farmer's age, education level and gender. Only 32.60 percent of the total changes in the rice yield are accounted for by factors outside the model. Further, the F- statistics of the model indicates that all the model independent factors jointly and significantly determine the rice yield levels since the probability value of the F- statistic is less than 5 percent significance level (Prob > F = 0.003).

4.5: OLS Model - effect of agricultural sustainable intensification practices in rice farming on farmers' income – Objective 2

In addition to the change in the rice yields, the study sought to examine the effect of the adoption of the System Rice Intensification and the Water Saving Rice Culture by farmers on the income levels of the farmers arising from the rice sale.

Results of correlations between farmers' income and components of System of Rice Intensification and Water Saving Rice Culture are presented in Table 4.4. The correlation between farmers' income and components of WSRC were positive and highly significant ($P < 0.01$) but weak for 30 x 15 cm spacing ($r = 0.22$) and for transplanting 2/3 seedlings ($r =$

0.14) and, non-significant for transplanting 21 day old seedlings ($r = 0.05$). The correlation between farmers' income and components of SRI were positive, weak and highly significant for transplanting 14 days old seedlings ($r = 0.36$) and transplanting single seed ($r = 0.10$) and, significant ($P < 0.05$), positive, and weak for using 25 x 25 spacing ($r = 0.11$). Within the WSRC components there was highly significant ($P < 0.01$) positive and strong correlations between transplanting 21 days old seedlings and spacing of 30 x 15 cm ($r = 0.90$) indicating that a combination of the two resulted to increased incomes.

Table 4.4 Correlation Analysis

	Income	14 days seedlings	21 days seedlings	Spacing 25 x 25	Spacing 30 x15	Single seed rate	Seedling 2/3
Income	1.0000						
14 days seedlings	0.3598 (0.0000)	1.0000					
21 days seedlings	0.0474 (0.7041)	0.2848 (0.0000)	1.0000				
Spacing 25 x 25 cm	0.1063 (0.0220)	0.2478 (0.0000)	0.6318 (0.0000)	1.0000			
Spacing 30 x15 cm	0.2247 (0.0050)	0.5094 (0.8341)	0.8961 (0.0000)	0.4384 (0.0000)	1.0000		
Single seed rate	0.0972 (0.0000)	0.5400 (0.8310)	0.1794 (0.4080)	0.1485 (0.0000)	0.3264 (0.0000)	1.0000	
Seedling 2/3 seeds	0.1413 (0.0030)	0.5749 (0.0000)	-0.4489 (0.0000)	0.3384 (0.0701)	0.3327 (0.0000)	0.2314 (0.2701)	1.0000

The OLS regression model results for the effect of the farming practice on farmers' income are presented in Table 4.5. From the findings of this study, the OLS model results indicated that components of system of rice intensification as represented by transplanting 14 days old seedlings, spacing of 25 x 25 cm and transplanting a single seedling per hill had an effect on rice income. Adoption of transplanting a single seedling per hill had a positive and significant ($p < 0.05$) effects on rice income recording an increase of 1.908 percent holding other factors constant. The effects of transplanting 14 days old seedlings and using 25 x 25 cm spacing on farmers' income were positive but non-significant.

Table 4.5: OLS regression for income increase

Income	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
14 days seedlings	1.320	2.585	0.51	0.311	-6.4646	3.82336	ns
Spacing 25 x 25	0.919	1.991	0.46	0.121	-9.8832	-1.95659	ns
Single seed rate	1.908	1.564	1.22	0.026	-7.5234	-1.34019	**
21 days seedlings	0.514	2.581	0.19	0.014	-1.37791	3.65093	**
Spacing 30 x 15	-1.431	0.586	-2.44	0.000	1.56321	6.54254	***
Seedling 2/3 seeds	1.934	0.337	1.29	0.857	-1.7200	2.06900	ns
Age of farmer	4.268	0.690	1.83	0.050	-0.2029	1.82879	*
Education level	0.240	2.925	0.08	0.039	8.06964	31.6041	**
Gender (male)	0.519	1.524	0.34	0.023	16.3754	21.9095	**
Constant	1.150	1.4223	0.81	0.000	86.6014	143.000	***
R-squared		0.612	Number of obs			339.0	
Adj R-squared		0.5877	Prob > F			0.000	
F-test		4.612					

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Source: Author's computation (2019).

Regarding the Water Saving Rice Culture, the OLS model results showed that transplanting 21 days old seedlings, spacing of 30 x 15 cm and transplanting 2/3 seedlings per hill had effects on rice income. Of the three components, adoption of 30 x 15 cm spacing had a negative and highly significant ($p < 0.01$) effect on farmers' income recording a decrease in farmers' income of 1.431 percent holding other factors constant. Adoption of transplanting 21 days old seedlings showed a positive and highly significant ($p < 0.01$) effects on farmers' income, recording an increase in farmers' income of 0.514 percent holding other factors constant. The component of transplanting 2/3 seedlings per hill had a positive but non-significant effect on farmers' income.

On social economic factors farmers' age, education level and gender showed a positive and significant effects on farmers' income. Education level and gender had a positive and highly significant effects on farmers' income indicating that farmer's income increased among male farmers and with a higher education level. Regarding gender, male farmers we found to likely have more income under the WSRC and SRI practices compared to their counterpart female farmers

The additional model information asserts that 61.2 percent (Coefficient of determination R²) of the total changes in the rice income levels are accounted for by the changes in the System Rice Intensification and the Water Saving Rice Culture adopted by the farmers and farmer's age, education level and gender. Only 38.80 percent of the total changes in the rice yield are accounted for by factors outside the model. Further, the F- statistics of the model indicates that all the model independent factors jointly and significantly determine the rice income levels since the probability value of the F- statistic is less than 5 percent significance level (Prob > F = 0.000).

4.6: OLS Model – the effect of social economic factors on farmers’ yield and income –

Objective 3

Results of correlations between social economic factors and farmers’ paddy yield and income are given in table 4.6 and 4.7 respectively. The correlation between farmer’s paddy yield and age, education and gender were moderate, positive and non-significant ranging from $r = 0.43$ to $r = 0.47$. The correlations between farmer’s income and age was moderate, positive and significant ($P < 0.05$) while the correlation was positive and non-significant for education and gender.

Table 4.6 Correlation between farmer’s paddy yield and social economic factors

	Yield	Age	Education	Gender
Yield	1.0000			
Age	0.4651	1.0000		
Education	0.4426	0.6151	1.0000	
Gender	0.4315	0.3765	0.4927	1.0000

Table 4.7: Correlation between farmer’s income and social economic factors

	Income	Age	Education	Gender
Income	1.0000			
Age	0.3819	1.0000		
Education	0.5179	0.6151	1.0000	
Gender	0.4116	0.3765	0.4927	1.0000

The social economic factors age of the farmer, education level and gender accounted for 65% of the explained variability in farmers’ paddy yield observed among the respondents. The regression model was statistically significant ($P < 0.01$) indicating that the model applied statistically significantly predicted the dependent variable. The factor age of the farmer showed a positive and significant ($p < 0.05$) effects on farmers’ paddy yields recording an increase in farmers’ paddy yields of 0.071 percent holding other factors constant. The level of education also had a positive and significant ($p < 0.01$) effects on farmers’ paddy yields recording an increase in farmers’ paddy yields of 0.102 percent holding other factors constant. The factor gender showed a positive but non-significant effect on farmers’ paddy yields.

The OLS regression on social economic factors age of the farmer, education level and gender accounted for 50% of the explained variability in farmers’ income observed among the respondents. The regression model was statistically significant ($P < 0.05$) indicating that the model statistically significantly predicted the dependent variable. The factor age of the farmer

showed a positive and significant ($p < 0.1$) effects on farmers' incomes recording an increase in farmers' income of 0.079 percent holding other factors constant. The factors level of education and gender showed a positive but non-significant effect on farmers' paddy yields.

Table 4.8: OLS regression for yield increase

Yields	Coef.	St.err.	t-value	p-value	[95% Conf	Interval]	Sig
Age of farmer	0.071	0.070	1.01	0.013	0.067	0.208	**
Education level	0.102	0.063	1.61	0.009	0.023	0.226	***
Gender (male)	0.002	0.043	0.05	0.961	-0.083	0.087	
Constant	2.378	0.504	4.72	0.000	1.387	3.369	***
R-squared		0.514	Number of obs			339.000	
F-test		2.904	Prob > F			0.003	
<i>*** p < 0.01, ** p < 0.05, * p < 0.1</i>							
Mean dependent var			3.798	SD dependent var		1.022	
R-squared			0.654	Number of obs		339	
F-test			5.395	Prob > F		0.000	

Table 4.9: OLS regression for income increase

Income	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Age of farmer	0.079	0.040	1.96	0.051	0.000	0.158	*
Education level	0.030	0.033	0.90	0.368	-0.094	-0.035	
Gender (male)	0.042	0.034	1.26	0.209	0.024	0.109	
Constant	2.844	0.402	7.08	0.000	2.051	3.636	***
<i>*** p < 0.01, ** p < 0.05, * p < 0.1</i>							
Mean dependent var		2.7532		SD dependent var		1.304	
R-squared		0.5027		Number of obs		339	
F-test		0.0929		Prob > F		0.045	

CHAPTER FIVE

DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the discussion based on the results/findings presented in the chapter 4 of this study. It contains the summary of the findings based on the three objectives namely; the effects of adopting SRI, WSRC and socio-economic factors on rice farmers' yields and income in Mwea irrigation scheme. Further the chapter contains conclusion and recommendations. Recommendations are broken into five key areas namely, recommendation for farming practice, policy, various stakeholders, and contribution to literature and suggestions for further research.

5.2 Summary of findings

Out of the 400 rice farmers target sample for the study, only 339 farmers gave full responses to the questionnaire translating to the response rate of 84.75 percent. From this study majority of the rice farmers interviewed who were members of the Mwea Rice Growers Cooperative were men. This study showed that farmers' paddy yield and income had moderate, positive and non-significant correlation with the social economic factors age, education level and gender. Further analysis using the OLS regression model to determine the effects of each social economic factor on farmer's paddy yield and income revealed that age of the farmer had a significant contribution to increased paddy yield and income at farmer level while level of education had a significant contribution to increased farmers' incomes. The farmers interviewed adopted a mixture of components from SRI and WSRC. Majority of the farmers adopted transplanting 21 days old seedlings, spacing of 25 x 25 cm and 2/3 seedlings per hill.

This study showed that farmers' paddy yield and income had a weak, positive and significant correlation with the three components of SRI examined except for a weak and non-significant correlation between farmer's income and 25 x 25 cm spacing. Further analysis using the OLS regression model to determine the effects of each practice to farmer's paddy yield and income revealed that the practice of using 25 x 25 cm spacing had a significant contribution to increased paddy yield at farmer level while adoption of transplanting a single seedling per hill significantly contributed to increased farmer's income.

On the components of WSRC this study showed that paddy yield realised by the farmers had a positive and significant correlation with the practice of transplanting 21 day old seedlings. In contrast the correlation was negative and significant for using 30 x 15 cm spacing and non-significant for transplanting 2/3 seedlings per hill. The correlation between farmers' income were

weak, positive and significant for 30 x 15 cm spacing and for transplanting 2/3 seedlings. Transplanting 21 day old seedlings showed a non-significant correlation with farmer's income. Further analysis using the OLS regression model to determine the effects of the components of WSRC to farmer's paddy yield and income revealed that the practice of transplanting 21 days old seedlings and 2/3 seedling per hill had a significant contribution to increased paddy yield at farmer level while adoption of transplanting 21 days old seedlings and spacing of 30 x 15 cm significantly contributed to increased farmer's income.

5.3 Discussion of Findings

5.3.1 The effects of adopting SRI on rice farmers yields and income in MIS

This study established that the three components of SRI had a positive correlation with farmer's paddy yield and income. However, the correlations were insufficient in determining whether the components contributed significantly to farmer's paddy yield and income. The OLS regression model showed that the practice of using 25 x 25 cm spacing had a significant contribution to increased paddy yield at farmer level while adoption of transplanting a single seedling per hill significantly contributed to increased farmer's income. These findings concur with other researchers who reported that spacing of 25 x 25 cm resulted to higher paddy yields compared to a narrow spacing of 20 x 20 cm (Dass and Chandra, 2012; Thakur *et al.*, 2010). A 25 x 25 cm spacing provides a wider spacing resulting to a well-developed root system, more productive tillers, (Dass and Chandra, 2012), higher number of functional leaves and leaf area which increase the photosynthetic rate resulting to higher yields. The findings that transplanting a single seedling per hill significantly contributed to increased farmer's income have also been reported by Ndiiri *et al.*, 2013 and Mwatete *et al.* 2017. The increase in farmer's income is partly attributed to a reduction in seed requirement of up to 87% (Ndiiri *et al.*, 2013). This study revealed that farmers who adopted SRI practices and combined planting single seedling per hill with 25 cm by 25 cm spacing were more likely to experience an increase in the rice yields and incomes compared to the farmers who had not adopted the practice; this agrees with Kombe 2012, who reported an increase in yields from 3.83t/ha to 6.3 t/ha in Tanzania. Mwatete *et al.* 2017 reported an increase in yields between 35-53% in Mwea Kenya. According to Ndiiri *et al.*, 2013 SRI practices of planting younger seedlings, with wider spacing and intermittent irrigation, lead to increased paddy rice yields with concomitant rise in the income accruing to farmers.

In addition, the study identified that the quality of the rice produced affected the price it fetched in the market and thus even if a farmer adopted all the components in SRI while the quality of rice was low then the income was ultimately low, this agrees with Mwatete et al, 2017 who showed the importance of rice quality to meet consumers' needs.

The study also brought about other factors like cost of production, pricing constrained capital and market structures also affected the farmers income, Kuria et al 2003 and Onyango 2014 shows that an increase in cost of production results in decrease in farmers income. NIB 2019 compared locally grown rice pricing and the imported rice and noticed locally grown rice is highly priced at ksh 150 compared to ksh 100 imported rice. Omondi 2013 shows the benefits of organized market structures which mops off the rice in developed countries as opposed to unstructured market platforms in Kenya thus affecting the farmers' income.

5.3.2 The effects of adopting WSRC on rice farmers yields and income in MIS

Regarding the Water Saving Rice Culture, the three components transplanting 21 day old seedlings, 30 x 15 cm spacing and 2/3/ seedling per hill had a positive correlation with farmer's paddy yield and income except for a negative correlation between 30 x 15 cm spacing and farmer's paddy yield. The OLS regression model showed that the practice of transplanting 21 days old seedlings contributed positively to paddy yields and incomes indicating that farmers who adopted this practiced experienced increased paddy yields and incomes compared to those who did not adopt the practice. According to Asbur 2018, seedling number per hill and seedling age affect grain yield and that transplanting 21 days old seedling at one seedling per hill significantly increased grain yield as a result of increased number of productive tillers

The study also showed that adoption of 30x15 cm spacing is detrimental to yields and income, actually farmers who adopted this had low yields and income. This agrees with JICA 2016 who showed that 30x15 cm spacing in WSRC was wide and thus low crop population resulting to low yields and consequently low incomes.

The study also showed that there was significant environmental destruction due to over use of mechanization especially on destruction of soil structure and thus significant low production. This agrees with JICA 2016 who showed the significant destruction of soil structures and thus promoted friendly technologies that are environmental friendly e.g. precision agriculture.

5.3.3 The effects of socio-economic factors on farmers yields and income in MIS

The study showed that the age of the farmer contributed to increased paddy yields and incomes indicating that older farmers happened to record increased yields and income. However, this

disagrees with Omwega 2014, Mati 2011 and Rana 2014 who observed that younger farmers tended to adopt new technologies more easily thus high yields and incomes; in addition, the study showed that the average age of rice farmers is 47 years as opposed to other value chains whose average age is 60 years and thus this could contribute increase in yields and incomes; this could be high mechanization and adoption of technologies that attract the young people in agriculture.

The increase in paddy yields and income at farmer level observed in this study could be attributed to the experience gained by older farmers' in rice cultivation resulting to high paddy yields and incomes over time. This study also observed that the level of education contributed to high yields indicating that the highly educated farmers realised increased yields. This agrees with Alemu, 2011, who reported that education helps in disseminating technologies and not adoption of the same. On gender, the study showed that male farmers tend to have increased yields and incomes compared to their female counterparts, this agrees to Omwenga 2014 and Omondi 2014 who said male farmers have access to land and capital thus makes decisions on rice production compared to female farmers. Further the study showed that farmers who had access to agricultural extension and were in farmers groups/ co-operatives happened to have increased yields and incomes. This agrees to Pandey 2010 and Shemahonge who said that constant extension and research improves adoption of technologies and thus improves yields of a given value chain.

In addition, lack of capital and land fragmentation affected rice production in a negative way according to the study, this agrees with Onyango 2014 and Omondi 2013 who attributed low rice production in Ahero due to land fragmentation and lack of capital to women and youths.

5.3.4 Conclusions

This study wished to establish whether ASIPs i.e. SRI and WSRC adoption increases farmers yields and income; the findings confirms that the technologies increased yields and income however not all components under each technology was significant and thus farmers tended to adopt 14 days seedlings, 25x25 cm spacing and single seedling per hill in SRI; for WSRC only 21 days seedlings and 2/3 seedlings per hill was adopted. Both technologies also emphasized use of line planting however, farmers preferred random planting and also application of manure.

The study therefore proposes use of combination of technologies as opposed to single use of one technology i.e. combine both SRI and WSRC components which were significant to yields and

income i.e. 14- 21days old seedlings, single seedling and at 25x25 cm spacing . This agrees with Donkoh et al 2019, who said some components of given technology may not be compatible with a given population and thus it will not be adopted. For the ASIPs to be adopted only compatible components should be promoted.

Further other technologies like high yielding varieties should be promoted since they guarantee increased yields and incomes.

In addition, younger farmers are being attracted to rice farming in Mwea since the average age is at 47 years as opposed to other value chains whose average age is 60 years; these could be attributed to adoption of technologies and mechanization in the rice farming in the region and it can be replicated to other schemes to attract younger farmers in agriculture.

5.4 Recommendations

This section covers the researcher's recommendations to policy, various stakeholders, for daily practice and suggestions for further research based on the study objective, the result findings and discussions.

5.4.1 Farming practice

Promotion of good agricultural practices in the rice value chain would increase production and productivity in that; the use of organic manure would improve soil structure; promotion of minimum tillage, conservation agriculture would in a big way conserve the environment and thus guarantee rice production.

Combination of practices at primary production increases chances of increased yields and ultimately increased incomes. Farmers should adhere to practices that guarantees yields, conserves environment and also mitigates against the harsh climatic conditions; Both SRI and WSRC workable components should be replicated to other rice growing schemes in the country and region i.e 14- 21days old seedlings, single seedling and at 25x25 cm spacing.

Farmers should get access to high yielding and climate smart varieties to boost their production to meet the high demand, and also gain more from the constant cost of production.

5.4.2 Other stakeholders

Public private partnership should be encouraged since the entire rice value chain requires involvement of both public and private sector so as to make it more vibrant. Private sector can

get involved in seed system, rice processing, breeding, transportation, modern E-extension, storage, and marketing.

Involvement of market led breeding for rice would create a match of the varieties grown and the consumers' preferences and thus the whole value chain would be in sync.

5.4.3 Policy

Having unrestricted imports flood the market it makes it difficult for the farmers to dispose-off their produce. The policy makers should formulate import windows to restrict importation of unnecessary rice and create market for the locally grown rice and thus safeguard the small-scale rice farmer.

On the issue of inputs, enforcement of Warehouse receipt system would allow the farmers access inputs after delivering their produce in a warehouse using a receipt and after the produce is sold a better price the farmer is paid the dues. This system would promote productivity since necessary inputs can be accessed and also scrap off brokers who exploits farmers.

Land fragmentation policy would safeguard production since the land under rice production is continually getting smaller through family fragmentation and thus commercial rice farming will be impossible. A policy should be put in place to bar farmers from unnecessary land fragmentation so as farmers can enjoy economies of scale.

5.4.4 Suggestions for Further research

- i. To assess the determinant of continued farming of old rice varieties against adoption of improved varieties.
- ii. To assess the influence of hard labour on youth in the rice value chain.
- iii. To determine the effect of land tenure system in rice production in Kenya.
- iv. To study the effect of inorganic rice farming on soil and human health.

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(AIC Unsyiah) 2013 In conjunction with The 2nd International Conference on Multidisciplinary Research (ICMR) 2013 October 2-4, 2013, Banda Aceh, Indonesia

APPENDICES

APPENDIX A: Introduction Letter

Joseph Maina Ndung'u

Strathmore University

Nairobi

February, 2020

Dear Respondent,

RE: Questionnaire for Rice Farmers at the Mwea Irrigation Scheme

My name is Joseph Maina Ndung'u and I am a graduate student at the Strathmore University. I am conducting a field research on the **effects of adopting agricultural sustainable intensification practices on farmers' yields and income**. I kindly request the cooperative's permission to circulate a questionnaire to its member farmers for the purpose of obtaining insight & gathering data for my research project.

The information I collect will assist me to fulfil the course-work requirement towards the completion of a Degree in Masters of Management in Agribusiness. These research findings will also assist farmers, government and private stakeholders in understanding the need of deploying improved technologies and planning well for it, as we work towards small scale farmers' incomes.

The information that I will gather will be treated with strict confidentiality, owing to its nature and bound by the trust that the cooperative and respondents have bestowed upon me.

Thank you in advance for giving me this opportunity to circulate my questionnaire. It is my sincere hope that the outcome of this research will be beneficial to the larger rice industry, as well.

Sincerely,

Joseph Maina Ndung'u

Appendix B: Strathmore Ethical Approval



Strathmore
UNIVERSITY

19th May 2020

Mr Ndung'u Joseph
ndungu.joseph@strathmore.edu

Dear Mr Ndung'u,

RE: The Effect of Adoption of Agricultural Sustainable Intensification Practices on The Mwea Rice Farmers' Yields and Income in Mwea Irrigation Scheme


This is to inform you that SU-IERC has reviewed and **approved** your above research proposal. Your application approval number is **SU-IERC0815/20**. The approval period is **19th May 2020 to 20th May 2021**.

This approval is subject to compliance with the following requirements:

- i. Only approved documents including (informed consents, study instruments, MTA) will be used
- ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by SU-IERC.
- iii. Death and life threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to SU-IERC within 72 hours of notification
- iv. Any changes, anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to SU-IERC within 72 hours
- v. Clearance for export of biological specimens must be obtained from relevant institutions.
- vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.
- vii. Submission of an executive summary report within 90 days upon completion of the study to SU-IERC.

Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) <https://oris.nacosti.go.ke> and also obtain other clearances needed.

Yours sincerely,

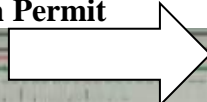

for: Dr Virginia Gichuru,
Secretary; SU-IERC


Cc: Prof Fred Were,
Chairperson; SU-IERC

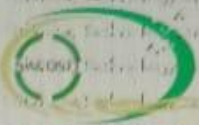


Ole Sangale Rd, Madaraka Estate. PO Box 59857-00200, Nairobi, Kenya. Tel +254 (0)703 034000
Email info@strathmore.edu www.strathmore.edu

Appendix C: NACOSTI Research Permit





REPUBLIC OF KENYA


NATIONAL COMMISSION FOR
SCIENCE, TECHNOLOGY & INNOVATION

Ref No: 266203 Date of Issue: 28/May/2020

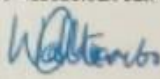
RESEARCH LICENSE




This is to Certify that Mr. Joseph Maini Ndung'u of Strathmore University, has been licensed to conduct research in Kirinyaga on the topic: Effects of adopting agricultural sustainable intensification practices on farmers' yields and income for the period ending : 28/May/2021.

License No: NACOSTI/P/20/5057

Applicant Identification Number: 266203


Director General
NATIONAL COMMISSION FOR
SCIENCE, TECHNOLOGY & INNOVATION

Verification QR Code



NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

APPENDIX B: Questionnaire

No.....

INSTRUCTIONS: For all the sections, please indicate by ticking the box that corresponds to your answer to the question, also give any comments you may have for the questions that have a blank space.

Date of interview: D/M/Y..... Enumerators/interviewer's

Name:.....

Sub-county:.....Location:.....village:.....

SECTION I:

A. Social Economic Characteristics of the Farmer

Age (years.) Male Female

Marital status.....Years of education.....Household size.....

Size of land holding (Acres)..... Size of land under rice (Acres).....

How many years in rice farming?

B. Rice Variety Grown

Which variety (s) of rice do you grow in your farm?.....

Rice Yields

Rice productivity in the last cropping season 2019/2020

Rice variety	Area planted (1acre)	Seeds in Kgs	Source of seeds	System used 1. CF 2. SRI 3. WSRC	Yield or production in (Kg)	Average cost of production (ksh)	Price/unit (ksh)	Gross income (ksh)

SECTION 2: Agricultural Practices

Which agricultural practice do you use in growing your rice (Please tick)?

1. CF – conventional farming { } 2. SRI -system rice intensification { } 3. WSRC- water saving rice culture { }

A. CF – CONVENTIONAL FARMING

(i) For CF please indicate the usage of the practice

CONVENTIONAL FARMING (CF)	Do you use this practice in your farm? Yes or No	Year you started using this technology	Reasons for using this practice
Transplanting seedling (21-28 days old)			
Spacing (20cm x 20cm)			
Seed Rate (Please Indicate)			
Broadcasting method			
Use of organic fertilizer			
Continuous flooding			
Weeding (Manual or Mechanical)			

B. SRI – SYSTEM RICE INTENSIFICATION

(i) For SRI please indicate the usage of the practice

SYSTEM RICE INTENSIFICATION (SRI)	Do you use this practice in your	Source of tech (Use the codes)	Year you started using this technology	If you did not use SRI In 2017/18/19 season and why

	farm? Yes or No			
Young seedling (14 days old)				
Wider spacing (25cm x 25cm)				
One seedling per hill				
Use of organic fertilizer				
Wet and drying (Intermittent irrigation)				
Mechanical weeding				

Codes on source of information on technologies 1 = Rice-MAPP; 2 = MIAD; 3 = Extension; 4 = Fellow Farmer; 5 = others indicate?

(ii) **In your opinion what makes you to adopt/not adopt SRI practices in your farm?**

Adopters			Non-adopters		
	Yes	NO		YES	NO
Increased income			Low income		
Increased yields			Low yields		
Prestige			No Prestige		
Affordable			High cost		
Available			Not available		
Easy to practice			Complicated		

Other			Other	
-------	--	--	-------	--

C. WSRC – WATER SAVING RICE CULTURE

(i) For WSRC please indicate the usage of the practice

WSRC	Do you use this practice in your farm? Yes or No	Source of Practice (Use the codes)	Year you started using this practice	If you did not use WSRC in 2017/18/19 season and why
Young seedling (21 days old)				
Wider spacing (30cm x 15cm)				
2 to 3 seedling per hill				
Use of organic fertilizer and modified split application of chemical fertilizers				
Wet and drying (Intermittent irrigation)				
Mechanical weeding				

Codes on source of information on technologies 1 = Rice-MAPP; 2 = MIAD; 3 = Extension; 4 = Fellow Farmer; 5 = others indicate

(ii) In your opinion what makes farmers to adopt WSRC practices in their farms?

Adopters				Non-adopters		
	Yes	NO			YES	NO

Increased income				Low income		
Increased yields				Low yields		
Prestige				No Prestige		
Affordable				High cost		
Available				Not available		
Easy to practice				Complicated		
Other				Other		

SECTION 4 – Practices adoption

1. In your opinion, how can the above practices be disseminated to farmers?

2. In your opinion, can rice production levels be improved by adoption of single type of practices or a combination of many practices?

- i. Improvement by a single practice
- ii. Improvement by a combination of practices

Explain your answer

3. In your opinion, what really determines adoption of sustainable intensification practices by a rice farmer in Mwea Scheme? -----

SECTION 5: (Effect on Farmers’ Income, Competitiveness and sustainability)

1. Kindly give a percentage on which the agricultural sustainable intensification practices affects or affected your yield and income?

None 1-9 % 10 -19 % 20 – 29 % 30-39 % 40 -49 % > 50 %

2. What do you term as the most evident measurable benefit of adopting sustainable intensification practices?

Improved Yields/ Production Larger Markets Improved Earnings/Income

Competitive Advantage

3. What other factors affects the rice farmer yields, sales and income?

Quality Of Rice Market Forces Rice Imports Value Addition Other

If other explain -----

5. In your opinion why should rice farmers practice sustainable intensification practices?

a) Environmental care (b) High population (c) Food security (d) Sustainable incomes (e) other
.....

6. How can we improve our locally produced rice competitiveness against imported rice?---

THE END

Thank you for your participation

APPENDIX D: Project Implementation Schedule

ACTIVITY	TIME FRAME		
	START	FINISH	DURATION
Proposal Development	October 2019	February 2020	Completed
Pilot Testing	February 2020	February 2020	1 week
Data Collection	February 2020	March 2020	3 weeks
Data Analysis	May 2020	June 2020	3 weeks
Project Finalization	June 2020	June 2020	2 weeks
Project Submission	June 2020	June 2020	1 day
Total Time			10 Weeks

APPENDIX E: Project Budget

ACTIVITY	Amount
Data collection printing	500
Pilot Testing	2,000
Data Collection	30,000
Data entry and Analysis	40,000
Project Finalization and printing	2,000
Transportation	10,000
Fees	5,000
Miscellaneous	10,000
Total	99,500

APPENDIX F: Payments to Participants

May, 2020

Dear Respondent,

RE: Payment to Participants

My name is Joseph Maina Ndung'u and I am a graduate student at the Strathmore University. I am conducting a field research on the **effects of adopting agricultural sustainable intensification practices on farmers' yields and income**.

This is to confirm that all enumerators will be paid Ksh 1,000 per day for their data collection work and they are expected to fill at least 20 questionnaires per day.

The respondents (farmers) will not be paid any money for responding to the researcher.

Sincerely,

Joseph Maina Ndung'u

APPENDIX H: Participant Information and Consent Form

Title of the study: Effects of adopting agricultural sustainable intensification practices on farmers' yields and income

SECTION 1: INFORMATION SHEET

Investigator: Joseph Maina Ndung'u

Institutional affiliation: Strathmore Business School (SBS)

SECTION 2: INFORMATION SHEET–THE STUDY

2.1: Why is this study being carried out? To investigate the effect of adoption of rice practices on farmers income and yields, and assist stakeholders in making right decisions in improving the whole rice value chain and to increase its contribution in national food security.

2.2: Do I have to take part?

No. Taking part in this study is entirely optional and the decision rests only with you. If you decide to take part, you will be asked to complete a questionnaire to get information on rice practices in your farm. If you are not able to answer all the questions successfully the first time, you may be asked to sit through another informational session after which you may be asked to answer the questions a second time. You are free to decline to take part in the study from this study at any time without giving any reasons.

2.3: Who is eligible to take part in this study?

- Rice farmers either adopters/non adopters of any practice in Mwea Irrigation Scheme

2.4: Who is not eligible to take part in this study?

- Anyone not a rice farmer

2.5: What will taking part in this study involve for me?

You will be approached by the investigator and requested to take part in the study. If you are satisfied that you fully understand the goals behind this study, you will be asked to sign the informed consent form (this form) and then taken through a questionnaire to complete.

2.6: Are there any risks or dangers in taking part in this study?

There are no risks in taking part in this study. All the information you provide will be treated as confidential and will not be used in any way without your express permission.

2.7: Are there any benefits of taking part in this study?

The information will be used to improve rice production in Mwea Irrigation Scheme.

2.8: What will happen to me if I refuse to take part in this study?

Participation in this study is entirely voluntary. Even if you decide to take part at first but later change your mind, you are free to withdraw at any time without explanation.

2.9: Who will have access to my information during this research?

All research records will be stored in securely locked cabinets. That information may be transcribed into our database but this will be sufficiently encrypted and password protected. Only the people who are closely concerned with this study will have access to your information. All your information will be kept confidential.

2.10: Who can I contact in case I have further questions?

You can contact me, **Joseph Maina Ndung'u** at SBS, or by e-mail *ndungu.joseph@strathmore.edu*, or by phone **0702192512** you can also contact my supervisor, **Prof. Simon Ndiritu** at the Strathmore Business School, Nairobi, or by e-mail *sndiritu@strathmore.edu* or by phone **0722590559**.

If you want to ask someone independent anything about this research please contact:

The Secretary–Strathmore University Institutional Ethics Review Board, P. O. BOX 59857, 00200, Nairobi, email *ethicsreview@strathmore.edu* Tel number: +254 703 034 375

I, _____, have had the study explained to me. I have understood all that I have read and have had explained to me and had my questions answered satisfactorily. I understand that I can change my mind at any stage.

Please tick the boxes that apply to you;

Participation in the research study

I AGREE to take part in this research

I DO NOT AGREE to take part in this research

Storage of information on the completed questionnaire

I AGREE to have my completed questionnaire stored for future data analysis

I DO NOT AGREE to have my completed questionnaire stored for future data analysis

Participant's Signature:

Date: ____/____/____

DD / MM / YEAR

Participant's Name:

Time: ____/____

I, _____ (Name of person taking consent) certify that I have followed the SOP for this study and have explained the study information to the study participant named above, and that s/he has understood the nature and the purpose of the study and consents to the participation in the study. S/he has been given opportunity to ask questions which have been answered satisfactorily.

Investigator's Signature: Investigator's Name.....

Date: ____/____/____

DD / MM / YEAR

Time: ____/____