Level of knowledge on application of sustainable agriculture practices among rice farmers in Mwea, Kirinyaga County, Kenya

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Abstract

Mwea Irrigation scheme is the largest in Kenya but rice yields have been declining over the years. The Government of Kenya has set to revive the scheme to increase and sustain rice production and enhance the livelihoods of the farmers. One of the factors to sustained production is adopting sustainable agricultural practices (SAPs). The objective of this research was to determine the level of knowledge on application of sustainable agriculture practices in rice farming in Mwea. Cross sectional design, proportionate stratified sampling technique and questionnaire were used to select and collect data from 144 rice farmers. Statistical tools such as frequencies, percentages, means, standard deviation and appropriate correlation coefficients were generated to describe and identify relationship among variables of the study. Results revealed that the knowledge level on SAPs among rice farmers is moderate. Farmers rely on their own experience in cultivating rice. The extent of application of SAPs is low. There is a strong positive relationship between knowledge and application of SAPs. This study recommends trainings for farmers on SAPs and a policy to encourage farmers to apply sustainable agriculture practices in rice production.

1.1 Background Information

Recent food crises and growing concerns about global climate change have placed agriculture on top of the international agenda (FAO, 2012). Few issues have aroused public concern in recent years more than the unforeseen and undesirable effects of today's agriculture on natural resources, environmental quality, and human and animal health. Specialization and dependence of conventional agriculture on off-farm inputs, especially synthetic chemical pesticides and fertilizer, have boosted food production to higher and higher levels. But costs have been incurred in the process, such as persistent soil erosion, groundwater contamination, loss of genetic diversity, and pesticide residues in food, loss of fish and wildlife, and growing uncertainty about the future productivity and profitability of farming itself. As a result, support grows among both farmers and non farmers for an agriculture that will continue indefinitely to be productive and profitable, conserve resources, protect the environment, and enhance the health and safety of the citizenry. That ideal is now widely referred to as “sustainable agriculture” (Schaller, 1991).

FAO (2011) defines sustainable agricultural development as "the management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such development... conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable."

According to Ikerd (2001) sustainable agriculture is about the environmental integrity, about economic viability, and about social responsibility, but ultimately, it’s about people. In other words, a healthy, diverse environment is necessary for the long run wellbeing of humans. If the natural environment – the soil, air, or water –is degraded, its ability to provide for the food and fiber needs of people is also degraded. If the quality of the environment – the purity of air or water –is destroyed, the health and wellbeing of people is degraded too. If other living species of the earth are destroyed, the ability of the earth to support human life is ultimately destroyed. The integrity of the natural ecosystem must be maintained in order to sustain its ability to sustain the life and health of people, because they are a part of the natural environment.

There are many agricultural practices that farmers can utilize to ensure production sustainability. Some of these practices include: practicing crop rotation, use of organic manure, use of fallow, non utilization of inorganic fertilizers, low tillage, use of green manure, retaining crop remains and wastes on farm after harvesting, protection of water quality and quantity, timing of planting and harvesting for pest control, non utilization of pesticides for disease and pest control (UCS, 2008).

For a rural community's development process to be sustainable, it must be linked to realization of values inherent in its geographically fixed resources. These resources represent the link between developmental purpose and place. Sustainable rural development must conserve non-renewable resources, protect the physical and social environment, provide an acceptable level of economic returns, and enhance the quality of life of those who work and live in rural communities (Ikerd, 2001).

1.2 Importance of Rice in Kenya

Rice is the third most important staple cereal in Kenya after maize and wheat. However, the country is only able to produce 20% of its national needs. Recent years have seen rice grow in importance in Kenya as per capita consumption, particularly in urban areas, has increased far more rapidly than that for other cereal crops (Kega, 2013). Rice supports many livelihoods as there are various actors in the value chain. According to EUCORD (2012), the main actors in the rice value chain in Kenya consist of input and service providers, primary producers, logistics centers and industries, traders and final consumers. Specific service providers consist of input merchants (agrovets and agrochemical companies), extension workers (government and private) and credit providers. Primary producers consist of tenant farmers/leaseholders, owner cultivators and farm workers. Logistics centers and industries consist of multi-purpose cooperatives, international and non-governmental organizations (JICA, FAO), the National Irrigation Board (NIB) and rice millers.

In Kenya, rice is grown by about 300,000 rice farmers, who provide labor and also earn their livelihood from the crop's production. Approximately 84% of the rice consumed in Kenya is produced on irrigated land with the remaining 16% being produced under rainfed conditions. The irrigated areas cover approximately 13,000 ha and include irrigation schemes in Nyanza West Kano and Ahero (at 3,520 ha), Western Bunyala scheme (at 516 ha) and Mwea irrigation scheme (at 9,000 ha). Upland rice is o grown in Migori and Kuria in Nyanza province, and Tana Delta and Msabweni in Coast province. Production is mainly by small-scale farmers. There are four major rice mills spread across the country with varying capacities. Lake Basin Development Authority has a milling capacity of 3.5 MT, Mwea National Irrigation Board (NIB) 24 MT, Western Kenya Rice mills 3 MT and Tana Delta with 3 MT per hour. Additionally, there are several small, privately-owned one-pass mills, especially in Mwea (ROK, 2012).

According to NIB (2012) report, the major traders of rice include the government-owned National Cereals and Produce Board (NCPB), National Irrigation Board (NIB) and Lake Basin Development Authority (LBDA) –through their rice mills in Ahero, Mwea and Kibos– which process and supply milled rice to supermarkets and local retailers; Mwea Farmers' Multipurpose Cooperative Society; supermarkets in major urban centers; Dominion Farms and Capwell Industries; among others. In addition, there are numerous small traders, mostly women, who sell rice in the local markets. The significant role rice plays in the livelihoods of all the players along the value chain can therefore not be overemphasized.

Mwea, which accounts for 80% of the rice production in Kenya (ROK, 2008), has had several challenges. Maina (2006) noted that land and water issues, old cultivation techniques, degradation of natural resources and environmental issues were the key challenges to sustainable agriculture and rural development in Mwea. Mohammed (2007) noted low and declining soil fertility; adulteration and low application of key inputs and slow adoption of appropriate technology. Average land area per household is 1.6 ha. Land allocation has remained static over the years, whereas population growth has increased at a faster rate. As a result, there has been an informal subdivision of land units within the irrigation scheme; land is increasingly rented out to other people by the official NIB tenant farmers, reducing some of these farmers to casual laborers on their own farms (EUCORD,2012).

Due to these challenges, there has been a continued decline in rice yields over the years leading to low returns and ultimately underdevelopment in the area (Mohammed, 2007). While a number of studies have recommended the application of appropriate sustainable agriculture practices to reverse the situation (Mati & Nyamai, 2009; Shalaby et al, 2011), reports still indicate continued low yields in this scheme (ROK, 2012). Despite low yields obtained by farmers, EUCORD (2012) asserts that rice cultivation remains the major livelihood for farmers in Mwea as it is generally profitable and therefore techniques need to be examined to increase rice output on farms and hence improve income and nutrition in the rice-producing households.

For rice farmers in Mwea to increase and sustain their rice output it's imperative that they employ sustainable agriculture practices. However the question is: Do the farmers know about these sustainable agriculture practices? If they do, are they using them? Is there any link between the level of knowledge a farmer has and application of these practices ? The aim of this study therefore was to determine the influence level of knowledge has on the extent of application of sustainable agriculture practices among the rice farmers in Mwea.

2.0 LITERATURE REVIEW

2. 1The Diffusion of innovations Theory (Rogers, 2003)

Diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system. Diffusion is a special type of communication concerned with the spread of messages that are perceived as new ideas. An innovation, simply put, is "an idea perceived as new by the individual." An innovation is an idea, practice, or object that is perceived as new by an individual or other unit of adoption. The characteristics of an innovation, as perceived by the members of a social system, determine its rate of adoption. The four main elements in the diffusion of new ideas are:(1) The innovation (2) Communication channels (3) Time (4) The social system (context). The characteristics which determine an innovation's rate of adoption are: (1) Relative advantage (2) Compatibility (3) Complexity (4) Trialability (5) Observability to those people within the social system.

Most individuals evaluate an innovation, not on the basis of scientific research by experts, but through the subjective evaluations of near-peers who have adopted the innovation. One of the ways in which the time dimension is involved in diffusion is in the innovation-decision process. The innovation decision process is the mental process through which an individual (or other decision making unit) passes from first knowledge of an innovation to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision. An individual seeks information at various stages in the innovation-decision process in order to decrease uncertainty about an innovation's expected consequences. 5-Step Process: (1) Knowledge – person becomes aware of an innovation and has some idea of how it functions (2) Persuasion – person forms a favorable or unfavorable attitude toward the innovation (3) Decision – person engages in activities that lead to a choice to adopt or reject the innovation (4) Implementation – person puts an innovation into use(5) Confirmation – person evaluates the results of an innovation-decision already made (Rogers, 2003). This theory applies to this study since the first (knowledge) and fourth (implementation) processes are evaluated.

2.2 Farmers' knowledge about Sustainable Agriculture

According to the Webster new world dictionary, knowledge is the general awareness or possession of information, facts, ideas, truths or principles. It is clear awareness or explicit information e.g of a situation or fact. According to Wintapo (2000) as cited in Ogunlade (2002), there are two perspectives of knowledge. These are knowledge as a state of knowing and a state of what is known. Knowledge as a state of knowing is produced by activities such as talking plus listening, writing plus reading and also activities such as discovering, inventing and intuiting. Ogunlade goes on to link knowledge with learning and posits that farmers learn a lot from their own experience and their own experiments, from watching what other farmers do and from discussion with other actors in the Agricultural Knowledge Information System (AKIS).

Many empirical studies involving knowledge have identified factors associated with knowledge level of an innovation by farmers. Educational level and exposure to information through mass media were found to have a positive and significant relationship with knowledge (Goswami & Sagar, 1994; Savanur e al., 1996; Singh et al., 1996; Pal et al., 1993; Patel & Ekpere, 1978).

In a research to study the attitudes and perceptions of farmers on the concepts and thoughts of sustainable agriculture and identifying effective factors on their attitude, Sadati (2010), revealed that there is positive correlation between literacy, participation in extension courses, off-farm income, farmer's knowledge about sustainable agriculture, level of use of sustainable agriculture methods, extension contacts and job satisfaction and negative correlation between age, experience in agricultural activities and family size. In view of the literature, this study will seek to determine the level of knowledge among rice farmers in Mwea and draws the hypothesis that the higher the educational attainment by the farmers, the more likely they are to have knowledge regarding sustainable agriculture practices.

In a study to determine the extent to which individual factors influence the adoption of sustainable agricultural practices in a West Virginia survey, D'souza, Cyphers and Phipps (1990) found that the effects of human capital characteristics were significant, while those for structural and institutional characteristics were not. However, the likelihood of adoption of sustainable agricultural practices was affected most by the environmental characteristic of whether or not the farmer was aware that ground water contamination existed on his farm.

2.3 Adoption Behavior of Farmers

Adoption may be defined in simple terms as the extent of use of a new technology or innovation. Feder et al. (1985), stress that "adoption takes place only in long run equilibrium when the farmer has full information about the technology and its potential." According to Parvan (2011), just as there are different types of technologies, there are different kinds of adoption. Feder et al. (1982) make three distinctions in types of adoption: 1) individual vs. aggregate adoption, 2) singular vs. packets of technologies available for adoption, and 3) divisible vs. non-divisible technologies. The first option is between final adoption at the individual level, which involves an internal deliberative process but is ultimately manifested as a dichotomous decision, and the aggregate adoption behavior observed as the diffusion of a technology, and its corresponding adoption, throughout a discrete space.

Further, Feder et al. (1982) explain that individual adoption can measure the degree of use in the long run, but it is ultimately a binary observation. Aggregate adoption, on the other hand, is measured as the aggregate level of use of a particular technology among one specific group of farmers or within one particular area. These farmers, whether observed individually or collectively, can choose to adopt in different ways. In some instances, farmers are presented with a single choice: the adoption of one discrete technology, but in most cases, agricultural technologies are introduced in bundles, and these bundles are often complementary. This gives farmers several distinct technological options, and it gives those trying to measure and model that adoption more to consider because farmers may adopt the complete package of innovation, they may adopt nothing, or they may pick subsets of bundles. This study will therefore seek to find the relationship between the most adopted technologies by hypothesizing that the sustainable agriculture technologies most farmers adopt are positively and significantly associated.

3.0 METHODOLOGY

This study adopted the cross sectional survey design. The target population in this study consisted of the 3242 rice farming households in Mwea, Kirinyaga County. Mwea is about 100 Km North East of Nairobi. Farmers in Mwea irrigation scheme predominantly produce rice since its inception in 1956.

The scheme has a total gazette area of 30,350 acres of which some 16,000 acres has been developed for paddy production. The scheme is divided into five (5) sections namely Tebere 3285 acres, Nguka 3110 acres, Thiba 3019 acres, Wamumu 2880 acres and Karaba 2650 acres. It supports approximately 3242 farm families (Kabutha & Mutero, 2012). All the land is held in trust by Kirinyaga County Council and the National Irrigation Board (NIB). Farmers are given licenses to till the land which can be passed to their children (NIB, 2012).

Farmers, partially or wholly dependent on rice cultivation to earn their livelihoods were sampled for this study. The household head was selected as the respondent.

Since the sample frame was known, probability sampling was done. The type of probability sampling that was used in this research was stratified sampling. In stratified sampling, the population was divided into sub populations such that the elements within each sub population are homogenous. Simple random samples were then selected independently from each subpopulation. Mwea scheme is divided into five (5) sections, (Tebere, Nguka, Wamumu, Karaba and Thiba), these were included in the study to form the strata. Sample size was determined using the formula (Amin, 2005)

$$n = \frac{Z^2.p.q.N}{e^2(N-1)+Z^2.p.q}$$

Where n= Sample size

Z= Std Variate at a given confidence limit (1.96 at 95%)

p= Sample proportion = 0.05

q= (1-p)=0.95

N= Size of population=3242

e= Maximum error=0.05

$$n = \frac{1.962*0.05*0.95*3242}{(0.05)^2(3242-1)+1.96^2*0.05*0.98} = 144$$

To sample proportionately from each section (Amin, 2005), the following calculation was made:

$$\frac{\text{No. of farm families in the section} * 144}{\text{Total No. of farm families in Mwea}}$$

Table 1: Sample Size Selected From Each Section of The Study Area

Section	**Tebere**	**Nguka**	**Thiba**	**Wamumu**	**Karaba**	**Total**
No. Farm families	707	672	653	626	584	3242
Sample size	30	30	28	28	28	144

Source : Field data, 2014

A questionnaire was the main instrument for data collection. Some items on the questionnaire were structured and others were open-ended. This format was selected to allow the respondents to express themselves freely. The other instrument that was used included unobtrusive observation to gather data on the living conditions of the rice farmers and the farming practices. Data was collected by the researcher. For farmers who cannot read and write, items on the questionnaire were asked in the local language. Descriptive and inferential statistical procedures were used for data analysis.

4.0 RESULTS

4.1 Knowledge level on Sustainable Agriculture Practices among rice farmers in Mwea

Knowledge and information are basic ingredients for increased agricultural production and productivity (Botlhoko and Oladele, 2013). Results in Table 3 present the knowledge of the farmers on SAPs in Mwea.

Table 3: Number of Rice Farmers in Mwea with Knowledge on Sustainable Agriculture Practices

SAP	Number of farmers with Knowledge	Percentage
Timing of production for crop protection	137	95.1
Use organic manure	133	92.4
Low tillage	126	87.5
Protection of water quality and quantity	107	74
Leave land fallow	105	72.9
Retain crop residues	93	65
Crop rotation	85	59.9
Integrated pest management	65	45.5
Recommended rates of fertilizers	57	40.1
Use green manure	52	36.4

Source: Field data, 2014

This study revealed that the most known SAP by the farmers was timing of production in order to minimize pest and disease attack (95.1%). The farmers attributed this knowledge to experience.

Most farmers know when to plant rice so that the crop is not severely affected by diseases and this is a very good practice as it minimizes the use of pesticides which are harmful to the environment.

Using organic manure for improving soil fertility was the second most known SAP by farmers. Organic manure especially farm yard manure and compost is a good source of plant nutrients and they also help to improve soil structure and texture. The more fertile the soil is the less the farmer is required to use inorganic fertilizers which are expensive and have negative effect on the soil if the recommended rates are not used.

The third most known SAP by farmers in Mwea was low tillage. Low tillage is a conservation agriculture technique that ensures that the soil is not very disturbed through several soil tillage practices thus maintains the soil structure. Conversely, the least known SAP was use of green manure. This is a practice that involves planting a leguminous fast growing crop after harvesting rice and then ploughing it in to provide nutrients for the subsequent rice crop. Some crops that can be used as green manure include cowpeas and lentils.

Most farmers knew at least five (5) out of the 10 SAPs selected for this study as indicated by the mean of 5.74 and Standard deviation of 1.33 as shown in table above. This implies that the variability between those who knew many of the SAPs and those who knew few was not great. To classify the farmers level of knowledge into low, moderate and high, the respondents having score in the range of (μ ± s.d) were categorised under medium knowledge level and those having score lower and greater than (μ ±s.d) were categorised under low and high knowledge level respectively. Results are as shown in Table 2.

Table 2: Level of Knowledge on Sustainable Agriculture Practices among Rice Farmers in Mwea

Level of Knowledge	Frequency	Percent
Low	20	18.1
Moderate	52	50.5
High	33	31.4

n=105, Scale: 0-4 SAPS= Low; 5-6 SAPS= Moderate; 7-10 SAPS= High
Source: Field data

Majority of the respondents had moderate level of knowledge. Table 3 shows the main sources of information for the farmers. Majority of the farmers (35.7%) rely on their own experience in rice cultivation and also on other farmers (34.3%). This implies that farmers may lack education that creates knowledge on new technologies. According to FAO (2001), education plays a key role in motivating adoption and requires tailored, credible, and appropriate information and experience that is communicated through the proper channels. Extension services to provide information and assistance can be highly effective, especially in the case of new or emerging technologies, although public agents need not be the exclusive providers of such services.

Table 3: Main sources of information for rice farmers in Mwea

Source of Information	Frequency	Percentage
Government extension officers	29	20.3
Educational institutions	8	5.6
Media (Radio or /and TV)	6	4.2
Other farmers	49	34.3
Own experience	51	35.7
Total	143	100.0

Source: Field data, 2014

4.3 Extent of Application of Sustainable Agriculture Practices among Rice Farmers in Mwea

In response to whether farmers in Mwea applied the selected SAPs in their rice farming, Table 4 shows the results.

Table 4: Number of Saps Applied By Rice Farmers in Mwea

SAP	*Number of farmers who applied	Percentage
Timing of production for crop protection	88	91.7
Use organic manure	85	85.0
Low tillage	74	78.7
Protection of water quality and quantity	71	71.0
Leave land fallow	69	66.3
Retain crop residues	55	56.1
Use green manure	42	43.6
Integrated pest management	22	21.2
Recommended rates of fertilizers	19	19.2
Crop rotation	15	14.4

*Multiple responses

The SAP that was most applied by farmers was timing of production, followed by use of organic manure and low tillage. Interestingly not all the farmers sampled for the study responded. Of the 137 who knew the “timing” SAP, 88 applied it in rice farming. In all the SAPs known by the farmers, less farmers applied them. The highest number of SAPs that were applied by farmers was eight (8) and some farmers applied none of the SAPs. However the average number of SAPs applied by the farmers was 5.06 with a standard deviation of 1.67.

To classify the farmers level of knowledge into low, moderate and high, the respondents having score in the range of (μ ± s.d) were categorised under medium knowledge level and those having score lower and greater than (μ ±s.d) were categorised under low and high application level respectively. Results are as shown in Table 5. The results showed that only 2% of the respondents had high application level of SAPs. This implies that the extent of application of SAPs among farmers in Mwea is low.

Table 5 : Extent of Application of Sustainable Agriculture Practices among Rice Farmers in Mwea

Extent of Application	Frequency	Percent
Low	32	30.5
Moderate	71	67.6
High	2	1.9

n= 105 Scale: 0-3 SAPS= Low; 4-6 SAPS=Moderate; 7-10 SAPS=High

For increased and sustained rice production, farmers should adopt technologies that are environmental friendly e. g improve soil fertility, socially acceptable and still give economic returns. When respondents who were not applying SAPs in their farms were asked why they did not apply, majority of them said they had no information. Others, due to many years of rice farming experience, perceived the practices they are presently using for example use of pesticides to be the only effective way of controlling diseases yet according to Tebeest, Guerber and Ditmore (2007), cultural strategies such as crop rotation, proper fertilization of crop (avoid overuse of nitrogen fertilizers) and maintaining a proper flood level for the crop have been shown to manage rice blast, an important disease of rice that has great potential threat for crop failure which none of the farmers can risk.

Results in Table 6 showed that rice production was perceived by majority of the farmers in Mwea to be decreasing which implies that production was not sustainable.

Table 6: Perception of Mwea Rice Farmers on Production Trends

Statement	Frequency	Percent	Cumulative Percent
Production is decreasing	57	39.6	39.6
Production keeps fluctuating	52	36.1	75.7
Production is increasing	27	18.8	83.5
Production is constant over the years	8	5.5	100.0
Total	144	100.0	

Source: Field Data, 2014

4.5 Relationship Between Level of Knowledge and Extent of Application of Sustainable Agriculture Practices in Mwea.

To determine the relationship between the level of knowledge and extent of application of SAPs among farmers in Mwea, a chi square test of association was done and results showed that they had a significant relationship (X2=50.14, p=0.000) as shown in Table 7. The gamma value illustrates a positive trend between the variables which reveals that with the increase in knowledge on SAPs, extent of application also increased among the farmers. This implies that farmers who had knowledge formed an attitude towards the practices and made a decision to implement them unlike those who had low knowledge. This is consistent with the adoption theory which posits that knowledge is the first step in innovation decision process. The study further confirmed the adoption theory that knowledge alone is not a determinant of adoption of an innovation by a farmer. Wandel and Smithers (2000) reported that awareness of sustainable techniques, did not necessarily lead to adoption.

Table 7: Relationship between level of knowledge and extent of application of Sustainable Agriculture Practices in Mwea

	Level of knowledge			Total	X^2	p-value
Extent of application	Low	Moderate	High			
Low	18 (95%)	11 (21%)	3 (9%)	32 (31%)	50.14	0.000*
Moderate	1 (5%)	42 (79%)	28 (85%)	71 (68%)		
High	0 (0%)	0 (0%)	2 (6%)	2 (2%)		
Total	19 (100%)	53 (100%)	33 (100%)	105 (100%)		

*Significant at p<0.05. Gamma Value 0.849

5.0 CONCLUSION

Farmers in Mwea have knowledge on sustainable agricultural practices. However the knowledge is not sufficient to inspire them to apply SAPS as the extent of application was low. There is a significant positive relationship between knowledge and application of SAPs among the Mwea rice farmers. Farmers own experience and other farmers were the main source of information for farmers. This study recommends that more trainings and demonstrations on sustainable agriculture practices in rice be done by the ministry of agriculture, county government of Kirinyaga and other development partners to increase farmers' knowledge and hence sustainable production of rice in Mwea.

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