Awareness and practices of Paddy Farmers towards Sustainable Agricultural Technologies: The Case of Usangu Plains in Mbarali district, Tanzania

Abbas Sanga*

*Department of Business Management, Mbeya University of Science and technology

Abstract:
Sustainable agricultural practices (SAPs) lie not in conserving but also in enhancing the natural resources without sacrificing yield levels. The adoption and diffusion of specific SAPs have become important issue in paddy production and productivity in Usangu Plains. However, Farmers' decisions to adopt a new agricultural technology depend on complex factors. One of the factors is farmers' perception (awareness and practices). The objective of this study was to investigate perceptions of farmers towards applying sustainable agricultural technologies in paddy farms and identify factors influencing their perceptions. Experimental research design was adopted. Stratified purposive sampling was used to collect data from a sample size of 120 farmers from Uturo, Ihahi and Ukwavila villages. Data were collected through household survey and key informants. SPSS 16.0 and STATA 11 packages were used for descriptive and quantitative data analysis, respectively. The results of the study show that farmers had positive perception about sustainable agricultural technologies such as diversification and rotation, application of manure but in general, they prefer modern technologies to local ones. They perceived agrochemicals as the best means to combat against pests and to increase rice production. Their perception of intangible impacts of modern technologies was weak. It was found that there should be a relationship between a numbers of socio-economic factors, such as human capital factors, information sources use, extension participation and landholding size and the perception towards selected sustainable agricultural technologies. Also, educational level, contact with agricultural experts and extension participation were best predictors of their perceptions.

Key words:
Perception, technology, sustainable agriculture, paddy farmers, farming practice

I INTRODUCTION

Rice is the world's most important food crop and a primary source of food for more than half of the world's population (FAO, 2014). In Tanzania, Rice is the third most important food crop after maize and cassava. Most countries in Sub-Saharan Africa (SSA), including Tanzania, heavily depend on agriculture that is dominated by subsistence smallholder farmers. The fate of the agricultural sector directly affects economic growth, food security, poverty alleviation, and social welfare. The performance of agriculture in this region has not lived up to expectations, characterized by decades of ups and downs. Its low level of productivity is emphasized by the statistic that while the sector employs about 67 percent of labor force, it contributes only about 17 percent of the total gross domestic product (World Bank 2007).

According to Lewis and Wilson (2013) Tanzania's annual production averages about 1.35 million tones, production doubled between 2001 and 2012 but this was due to increased area and not to increased yield. Most rice is grown by smallholders under rainfed conditions (74 per cent of the planted area) with irrigated (20 per cent) and large scale production (6 per cent) being of lesser importance. The Government of Tanzania has prioritized rice through its National Rice Development Strategy (2009a) which seeks to double rice production again by 2018 in order to provide food security and the possibility of export to neighbouring countries (Lewis and Wilson, 2013).

Similarly, according to the Ministry of Agriculture, Food Security and cooperative (URT, 2012a) the production of paddy in Mbeya region including Mbarali district has been declined gradually from 102,000 tonnes in 1994/95 to 41,000 tonnes in 1999/2000. However, there was a gradual increase in production between 2000 and 2002/03, thereafter, production of paddy shot up from about 63,000 tonnes in 2002/03 to 164,000 tonnes equivalent to 160 percent increase in 2007/08. The production was partly due to an increase in planted area from 54,743 ha in 2002/03 to 164,065 ha in 2007/08 as well as increase in yield per hectare from 1.15 t/ha to 2.02 t/ha. However, continued decline of soil fertility (depletion of soil nutrients and organic matter), low and poorly distributed rainfall, poor resource endowments, lack of or inadequate institutions, little or no use of fertilizer, production risk, and endemic crop and livestock diseases are major causes of the low and decreasing performance of Tanzania's agricultural sector (Binswanger and Townsend 2000; Ajayi, 2007; Misiko and Ramisch 2007). Soil fertility depletion is considered the main biophysical limiting factor for increasing per capita food production for most of the small Holder farmers in developing countries (Smaling et al. 1997; Kassie et al. 2012).

Thus, when no external inputs are used, plots require long fallow periods to replenish nutrients taken up by crops and washed away by erosion. However, as the population increases and the availability of new land to exploit decreases, allowing plots to lie fallow has become more and more difficult, and continuous cropping has become commonplace in Tanzania. This has resulted in a vicious cycle of poor agricultural productivity, low investment capacity, continued soil degradation, and further pressure on available lands to generate necessary food supplies (Misiko and Ramisch, 2007). These external inputs have, however, gradually substituted for natural processes and resources, rendering them less powerful. Pesticides have replaced biological, cultural and mechanical methods for controlling pests, weeds and diseases; inorganic fertilizers have substitute for livestock manures, composts, and nitrogen fixing crops (Rahiman, 2003, 2002).

The adoption and diffusion of specific sustainable agricultural practices have become an important issue in the development policy agenda for SSA (Aiayi, 2007), especially as a way to tackle these impediments. These practices are conservation tillage, legume intercropping, legume crop rotations, improved crop varieties, use of animal manure, complementary use of organic fertilizers, and soil and stone bunds (Wollni et al. 2010). In Tanzania, Agricultural sector development policy (ASDP) have been remarkably successful at emphasizing external inputs, such as pesticides, inorganic fertilizers, power tillers and tractors as the means to increase agricultural productivity, profitability and farm incomes (URT, 2006). Meanwhile, National Rice Development Strategy (NRDS) in the country address the need to increase food production to meet the food security objective in achieving self-sufficient in staple food production, particularly rice (URT, 2009).

The potential benefits of Sustainable agricultural practices lie not only in conserving but also in enhancing the natural resources (e.g., increasing soil fertility and soil organic matter) without sacrificing yield levels. This makes it possible for fields to act as a sink for carbon dioxide, to increase the capacity of the soil to hold water, and reduce soil erosion (Allmaras et al. 2000). Furthermore, by retaining fertile and functioning soils, SAPs can also have positive impacts on food security and biodiversity (Wollni et al. 2010). Crop rotation and diversification via intercropping enable farmers to grow products that can be harvested at different times and that have different climate or environmental stress -response characteristics. These varied outputs and degrees of resilience are a hedge against the risk of drought, extreme or unseasonal temperature, and rainfall variations that can reduce the yields of certain crops, but not others (Wollni et al. 2010).

The basic challenge for sustainable agriculture is to make better use of internal resources. This can be done by minimizing the external input used, by regenerating internal resources more effectively, or by combination of both (Roling and Pretty, 1997). Intensive nature of the rice cultivation process can impact the environment. Negative effects include reduced soil fertility, water pollution and the emission of green house gases. The intensive use of a limited number of high-yielding rice varieties over a wide-ranging area and prolonged period of time has reduced genetic diversity. Inefficient use of agrochemicals and pesticides results in pollution and directly harms farmers' health (Badawi, 2004).

Notwithstanding their benefits, the adoption rate of these technologies and practices is still low in rural areas (Tenge et al. 2004; Wollni et al. 2010), despite a number of national and international initiatives to encourage farmers to invest in them. The same is true in Tanzania, where, despite accelerated erosion and considerable efforts to promote various soil and water conservation technologies, the adoption of many recommended measures is minimal and continues to be a problem (Mbaga-Semgalawe and Folmer 2000; Tenge et al. 2004).

Therefore, the present paper investigated farmers' perception towards applying sustainable agricultural technologies and how they perceive these technologies, and to identify factors influencing their perceptions in the rural villages. The adoption decisions in question relate to legume crop rotations, animal manure, conservation tillage (zero/minimum tillage), soil and water conservation practices, chemical fertilizer, agrochemical and pesticides, and introduction of improved seeds (improved crop varieties). Understanding the perceptions of household choices of SAPs can provide insights into identifying target variables and areas that enhance the use of these practices.

II THEORETICAL FRAMEWORK

Sustainable agriculture has defined and described in many ways. For example, the American Society of Agronomy defined sustainable agriculture as the one that, over the long term: (1) enhances environmental quality and the resource base on which agriculture depends, (2) provides for basic human food and fiber needs, (3) is economically viable, and (4) enhances the quality of life for farmers and society as a whole (Dennis et al. 1996).

Absolute definitions of sustainable agriculture at global level and over time are not feasible (Cromwell et al, 2001). Despite the diversity in conceptualizing sustainable agriculture, there is a consensus on three basic dimensions of the concept (Hansen, 1996; Rigby, 2001; Wiren-Lehr, 2001; Zhen et al. 2005): (i) economic concerns over economic justice, the survival of owner operated farms, and the long-term profitability of agriculture; (ii) environmental concerns over adverse impacts of agriculture on land, water, and wildlife resources; and (iii) public welfare concerns over food quality and human exposure to toxic chemicals.

Environmental issues emerge from the human use of natural resources. According to Roling and Pretty (1997), sustainability emerges out of shared human experiences, objectives, knowledge, decisions, technology, and organization. Agriculture becomes sustainable only when people have reason to make it so.

Farmers' decisions to adopt a new agricultural technology in preference to other alternative (old) technologies depend on complex factors. One of the factors is farmers' perception of the characteristics of the new technology vis-à-vis that of the existing (old) technology [Rogers, 1995, Negatu and Parikh, 1999]. Smathers (1982) concluded in his study that, it was likely that the successful adoption of conservation practices would be influenced by a farmer's attitude and perceptions, than any other factor. Alonge and Martin (1995), found that farmer's perceptions regarding the compatibility of sustainable practices with their farming systems emerged as the best predictors of adoption of such practices. Sheikh et al [32] found that attitude towards the use of technology and contact with extension agents were the main factors influencing the adoption of no-tillage practice. Hence, there is a need to find out what farmers' perceptions are with regards to applying selected sustainable agricultural technologies.

Agricultural technology has defined as any behavior or practice that involves the interaction of individuals within the production system (CTTA, 1992). For the purpose of this study, sustainable agricultural technologies are represented by technologies which promote the sustainability of rice cropping systems. This paper intends to contribute to the existing literature by providing an empirical analysis of the possibility of applying sustainable agricultural technologies from the view points of paddy farmers. The results obtained in the analysis are used to develop recommendations for sustainability of rice cropping systems.

III METHODOLOGY

Mbarali District lies within 08 04 S and 34 38 E, is one of the districts of Mbeya Region. It is bordered to the north and East by Iringa Region, to the South by the Mbeya rural district and to the west by Chunya district. It covers an area of 15,560 Square kilometers and it has a total population of 300,517 inhabitants among these 145,867 are male and 154650 are female (URT, 2012b). In Usangu plains, the major food crops grown include rice, maize, sorghum, and beans. The major cash crops are sunflower and groundnuts. Other minor crops include onions, tomatoes, sugarcane, vegetables and fruits (mainly water melon, citrus, cucumber, mangoes and pawpaw). Irrigated crops include paddy, maize, beans, cassava, sweet potato, sugar cane, onions, and vegetables. Paddy is grown on the lower alluvial fans having clay soils, while maize and dry season crops are grown on the upper alluvial fans and foothills where the soils are sandy loams containing less clay (URT, 2012a).

Experimental research design was adopted. Stratified purposive sampling method was used in the selection and collection of data from the respondents in the present study. The questionnaires were self-administered in three villages namely; Uturo, Ihahi and Ukwavila each village with 40 respondents and a total number of 120 respondents who partially or wholly dependent to rice cultivation to earn their livelihoods were interviewed to get rice- based production systems. The sampled farmers were determined according to Cochran's formula. A questionnaire adopted from Bagheri (2008), included fixed- response and open- ended questions was the main instrument for data collection. To validate the instrument, the content validity was used. The instrument was validated by a team of experts consisting of two extension rice specialists from Uyole-Agricultural Research Institute. Earlier, a pilot study was conducted in one of the rural area with collaboration of 20 people. The aim of the pilot study was to test and improve the instrument. However, Cronbach's alpha computed to measure the reliability of perceptions towards sustainable agricultural technologies indicated that it was 0.85. It meant that index had high reliability. Having tested the questionnaire for validity and reliability it was filled out by researcher and then the collected data were analyzed. Farmers' perceptions towards sustainable agricultural technologies were operationalized as the extent of their agreement with the statements related to 10 selected indicators of sustainable agriculture. With consideration to rice cropping system's situation, the selected indicators of sustainable agriculture included negative effects of agrochemicals on environment and human health, reduced use of agrochemicals in agriculture, use of organic (animal and green) manure, retaining crop remains and wastes on farm after harvesting, low tillage, crop rotation and farm diversification, cultivation of legume after rice harvesting, biologic and agronomic control of pests. The perceptions of farmers towards selected sustainable agriculture indicators measured by some positive and negative statements. Box 1 depicts these indicators and it's statements. The respondents were asked to indicate the extent of their agreement on each indicator using a Likert-type five-points continuum like strongly agree, agree, undecided, disagree and strongly disagree with assigned scores of 5, 4, 3, 2 and 1, for positive statements, respectively and vice versa for negative statements

IV RESULTS AND DISCUSSION

The demographic characteristics of the respondents showed that they were low educated, fairly aged and experienced. About 34% of the respondents belonged to the age group ranging from 20 to 40 years old, followed by 37% and 29% to the age ranges in 41-50 and 51-81 years of age, respectively. The mean age of the respondents was 38.6 years. The results also showed that farming experience of 86.5% of the respondents was more than 10 years. Their mean years of farming experience were 22.7 years. In the case of education level, 10.6% of the respondents were illiterate. The education level of 76.5, 17.4 and 6.1% of them was primary, high school, and diploma, respectively. Generally, only 2.9% of the respondents were graduated from agricultural schools or colleges. This suggests that primary school leaver's constituted a large proportion of farmers, which implies that the majority of farmers could learn new skills. However, those with higher education tend to migrate to urban areas where they can engage with other economic activities or employment as reported in the URT (2009b). Regarding occupation, all of the respondents reported agriculture (rice cropping, gardening and livestock sector) as their major occupation This suggests that agricultural sector remains the main employer of the majority of respondents in the study area. Majority of Tanzanians (about 70% of the population) live and earn a living in rural areas, with agriculture as the mainstay of their living (World Bank, 2009).This implies that improvement in farm incomes of the majority of the rural population is a precondition for reduction of rural poverty in Tanzania (URT, 2012b). Whereas, due to small land holdings, 43.5% of them had non In the case of land holdings, there were two land possession systems: Land ownership and sharecropping systems. Regarding landownership, 7.7% of the respondents were landless, 48.2% of them owned less than one ha of rice farm, followed by 39.4% and 4.7% owned 1.1-3 and 3.1-6 ha of rice farm respectively, with a mean farm size of 1.4 ha. In the other words, the majority of them were small- scale farmers. Meanwhile, 73.5% of the respondents were working on their own farms, out of whom 26.5% regardless of having or not having owned farm, worked as labourers in farms. The respondents were asked to give their response on a Likert scale (never = 0, rarely = 1, sometimes = 2, often = 3 and always = 4) regarding their use or advisory contacts with the sources/channels of information. On the basis of CV (Coefficient of Variation) and mean, their contacts have prioritized.

The mean scores and CVs showed that consultations with other farmers and advisory contacts with district extension agents placed on the highest priorities of the respondents, respectively. Radio and TV's agricultural programs, consultation with family members and contact with local extension agents (co- extensions) were placed on the subsequent priorities. Other farmers who placed on the highest priority of the respondents' preference are not knowledgeable sources of information of sustainable agriculture. On the contrary, the most important source of information for sustainable agriculture i.e. agricultural publications had the least priority. It indicates that they had inadequate access to reliable information sources, such as extension, which may be due to their low level of literacy and inattentiveness to writing materials. It will be an alarming for agriculture to become sustainable. The respondents' participation in four extension activities surveyed on a Likert scale. According to the means and coefficients of variation (CV), their extension participation was prioritized. Participation in extension training courses enjoyed the highest priority. Participation in other activities was unnoticeable. According to the participation
scores, the respondents were grouped into four categories. The respondents who did not participate in extension were placed in the first group (low participation). The participation of 51.8, 8.2 and 3.5% of the other respondents were low, medium and high, respectively. It indicates that the paddy farmers in the study area had very low access to extension.

Box 1: Selected indicators of sustainable agriculture and their statements

Indicators	Statements: (Do you think :)?
Negative effects of agrochemicals	Agro-chemicals are pollutants of environment?
	Over use of agrochemicals is detrimental for human and animal health?
Reducing use of fertilizers	By decreasing chemical fertilizer use in long term paddy farmer's benefit will be increased (N)?
	Rice yield can be increased only by increased use of chemical fertilizer (N)?
Reducing use of pesticides	Pesticides use is the most appropriate method for pest control (N)?
	Herbicide use is the most appropriate method for weed control (N)?
	Pesticide overuse may be lead to pest resistant to pesticides?
Application of animal manure	Application of animal manure can increase soil fertility?
	Application of animal manure can not increase rice production (N)?
	A part of fertilizer needed for rice can be replaced by manure?
Increasing application of green manure	Because of presence of chemical fertilizer there is no need to green manure (N)?
	Soil fertility of paddy farm can be improved by application of green manure?
Retaining plant residues	Retaining the plant residues may increase weeds (N)?
	Release of crop residues in paddy farm will decrease soil fertility (N)?
	Rice pests' population can be controlled by retaining of crop residues in farm?
Minimum tillage	Minimum tillage reduces soil erosion, disturbance and exposure?
Crop diversification and rotation	Successive cultivation of a single crop causes pests' invasion to be increased?
	Crop diversification and rotation cause pests' invasion to be decreased?
	Crop diversification and rotation is cause of soil erosion (N)?
	Crop diversification and rotation decreases farmer's income (N)?
Cultivation of legume crops	Cultivation of legume crop improves soil fertility?
	Cultivation of legume crop causes pest's invasion to be increased (N)?
Integrated biological and	Biologic control and weeding of rice farm are the best methods of pest control?
Cultural pests' control	Winter plough of rice farm reduces damage of weeds and stem borer worm?

Table 1: Percent distribution of the respondents according to agreement with the statements of sustainable indicators (n=120)

Indicator	Statements (No.)	Strongly agree	Agree	Undecided	Disagree	Strongly disagree	Mean	CV	Rank
Negative effects of agrochemicals	1	17.6	24.7	15.9	30.6	11.2	3.07	.43	15
	2	52.9	40.6	1.8	2.9	1.8	4.14	.25	2
Reducing use of fertilizer	1	4.7	12.4	22.9	40.0	20.0	2.48	.45	17
	2	17.6	39.4	12.4	25.3	5.3	2.61	.46	18
Reducing use of pesticides	1	28.2	52.5	5.3	10.0	3.0	2.06	.49	21
	2	48.8	42.3	2.4	4.7	1.8	1.68	.52	23
	3	8.2	36.5	18.8	25.9	10.6	3.06	.38	11
Application of animal manure	1	35.9	52.9	2.3	7.1	1.8	4.14	.22	1
	2	2.4	17.6	3.5	67.1	9.4	3.64	.26	4
	3	4.7	34.1	6.5	46.5	8.2	2.81	.40	12
Increasing application of green manure	1	32.3	34.1	15.9	15.9	1.8	2.21	.50	22
	2	2.3	67.1	12.4	14.1	4.1	3.49	.26	5
Retaining plant residual	1	18.8	40.0	18.8	18.8	3.6	2.48	.45	16
	2	22.9	31.2	28.2	15.9	1.8	2.42	.44	17
	3	.60	2.9	14.1	40.0	42.4	1.79	.47	20
Minimum tillage	1	5.3	7.6	21.2	44.1	21.8	2.31	.46	19
Crop diversification and crop rotation	1	11.8	44.1	21.2	19.4	3.5	3.41	.30	7
	2	5.3	25.3	35.9	24.7	8.8	2.94	.35	8
	3	12.4	19.4	44.1	21.8	2.3	2.82	.35	9
Cultivation of regume crops	1	4.1	63.0	18.2	11.2	3.5	3.53	.25	3
	2	12.4	27.7	44.1	12.9	2.9	2.66	.36	10
Integrated biological and pests' control	1	1.2	24.7	22.9	32.4	18.8	2.57	.42	14
	2	5.9	52.9	17.1	20.6	3.5	3.37	.26	6

Perceptions of Sustainable Agricultural Technologies: Table 1 shows the respondents' perceptions towards sustainable agricultural indicators. In Table 1, numbers of statements related to each indicator inserted. The respondents' perceptions prioritized according to means and CVs. Because CV shows the variation of perceptions, lower CV, i.e. lower variation of the respondents' perceptions, for same mean, placed on higher rank. Because of belonging more than one statement to each indicator, it was not possible to organize statements according to their rank order. As data show, the respondents were fairly aware of the adverse environmental impacts of applying agrochemicals and their ingredients on human and animal health. As Rahman (2003) also found, while, their awareness remains mostly confined within visible impacts, their perception of intangible impacts was weak. As mean scores depicts, majority of the respondents were in agreement with the application of agrochemicals. They perceived agrochemicals as the best means to increase production at the present time. Most of them were against the idea of reducing the application of fertilizers and did not believe the process would lead to long term viable production. They insisted on insecticide application as the easiest way to combat against pests, despite the awareness that insecticides are the major environment pollutants and their over application makes insects resistant. This result was confirmed by Roling and Pretty (1997). Perceptions of the respondents about organic manure were analyzed associated with fertilizer. Mean scores of the influence of these manures on improving soil fertility indicates that the respondents had positive perceptions about it. In fact, the easy access to chemical fertilizer made negative perception about the application of these manures. Because, mean scores of replacing fertilizer by manure indicates that the respondents didn't consider a great weight for the manure. In fact, they perceived chemical fertilizer as a valuable elixir. Thus, in spite of positive perceptions about manure, as Roling and Pretty (1997) argued, agrochemicals as external inputs is substituting for natural processes and resources, rendered them less powerful. Despite the numerous emphases on retaining plant residues in the preservation of soil texture and nutrients, the respondents did not have very positive perceptions about it. Since incomplete decomposition of organic matter in marsh land, most of the respondents of lowlands were opponents to retaining of residue. They regarded setting fire on the plant residue as the easiest way to get rid of stem borer. Therefore, they should be taught the proper management of residues by the extension agents. Mean scores of minimum tillage showed that the respondents had poor perceptions about it. Most of them had not thought that the more tillage, the better bed for rice and the more rice yield. However, Hobbs et al. (1997) showed that minimum tillage was the best paddy residual management in regard to reduced costs and time, betterment of soil structure and drainage. Similarly, no tillage could be beneficial with higher seed density and proper fertilizer and weed management for medium texture soils. It should be added that in the study area often rice field tillage practice is done in the flooded plots with running irrigation water among plots after tillage. However improper soil tillage may result in soil structure demolition, splitting soil particles and reducing its hydraulic conductivity and led to erosion enhancement (Choudhary et al. 1997). There were different perceptions towards necessity of diversification and rotation in the rice- based farming systems. As mean scores and CVs show, most of the respondents were well aware that successive cultivation of a single crop causes an increase in pests' invasion. Also, a number of the respondents who applied diversification and rotation in their farming activities strongly emphasized that these practices had increased their farm's yield. Some of the respondents did not diversify their farms. Most of the respondents couldn't apply the method on their farms because of having small land size and flooded fields. Although 30.6 and 31.8 of the respondent were in agreement with decreasing of pest invasion and soil erosion by diversification and rotation, respectively; however, their perceptions was not very positive about such practices. Because soil erosion is an intangible problem, as Rahman (2003) showed, perception about intangible impacts are weak. In the case of pest control by diversification and rotation, as mentioned above, a group of respondents who had been benefited rotation in their farms were in agreement with the statement. Majority of the respondents perceived that legume crops can improve soil fertility. But most of them (59.9%) didn't believe that with rice- legume rotation, pest's population may be controlled. Most of the respondents had negative perception about biological control of rice pests. A small number of the respondents (25.9%) perceived that biological control is best way for control of pests' population under economic threshold. According to Table 1, scores of all respondents calculated. Then following analyses was carried out.

The results of correlation analysis in Table 2 depicts that there was significant relationship between perception towards sustainable agricultural technologies and variables consisting of age, educational level, educational, discipline, years of experience in agriculture, farmer's cultivated area, land ownership, diversity of farmer's rice varieties, off- farm income, contact with information sources/channels and extension participation.

As Table 2 depicts, there was significant negative relationship between age and experience and perception toward sustainable agricultural technologies ($p<0.01$). Education level and discipline had significant positive relationship with perception ($p<0.01$).This indicates that more educated farmers were younger and had more positive perception towards sustainable agriculture. There was significant negative relationship between farm size and perception ($p<0.05$). Also, there was significant negative relationship between landownership and perception. These results are confirmed by Carolan (2005). There was significant negative relationship between diversity of rice variety and landownership and participants' perception ($p<0.01$). Farmers who grew more than one rice varieties, at least one of those was improved variety which needed more external input, especially agrochemicals for more production, which is inconsistent with sustainability. Advisory contacts with district and ward agricultural experts, researchers and study of agricultural publications as sources of correct use of inputs had significant positive relationship with their perception ($p<0.01$), but contact with other farmers because of their insufficient scientific information negatively correlated with perception ($p<0.01$). Finally, extension participation and the respondent's perceptions were positively correlated.

In order to determine the factors that best predicted a farmer's perception towards the selected sustainable technologies, a multiple regression analysis with stepwise method was carried out. The regression model incorporated all of the independent variables which had significantly correlations with the perception. The dependent variable was the respondent's perceptions towards selected sustainable technologies index, which was defined as their scores obtained from the statements associated with ten selected indicators. As shown in Table 3, the positive and significant partial regression coefficients of educational level, extension participation and advisory contacts with experts of division agriculture management were found to have a positive effect on the respondents' perception scores toward selected sustainable agricultural technologies. The R2value of .618 with F value of 92.15 indicates the power of model for prediction its significance at .01 level of probability and reveals that 61.2 percent of variance in perceptions could be explained by these three variables. According to Table 3, the following equation was used to estimate of farmer's perception towards selected sustainable agricultural technologies: $Y = 47.975+ 3.543(X1) + 2.462(X2) + 1.458(X3) +e$.

According to the regression equation, educational level had a strong power in predicting farmers' perception followed by extension participation and contact with experts which are all related to the knowledge of the respondents.

Selected variables	r value
Age	384**
Education level	0.715**
Discipline	0.584**
Years of experience	-0.385**
Extent of cultivated area	-0.162*
Extent of landownership	-0.311*
Diversity of rice variety	-0.159**
Off-farm income	174**
Contact with ward agric.	0.331**
Experts	0.255**
Contact with District extension	0.285**
center	0.474**
Contact with Agr. Researchers	-0.140**
Agricultural publication study	0.542**
Contact with other farmers	
Extension participation	

Table 3: Results of regression analysis related to perception towards sustainable technologies

Var.	Predictor variables	B	Beta	t	p
-	Constant	47.975	-	32.962	0.01
X1	Education level	3.543	0.563	11.280	0.01
X2	Extension participation	2.462	0.359	70.128	0.01
X3	Contact with ward ext.off.	1.458	0.133	2.678	0.01

V CONCLUSION AND RECOMMENDATION

The study found that paddy farmers’ had negative perception toward some sustainable technologies such as minimum tillage, reduced use of agrochemicals, mixed use of organic and chemical fertilizer, biological and cultural control of pests. Meanwhile, paddy farmers’ had positive perception toward sustainable technologies like diversification and rotation, application of manure but in general, paddy farmers preferred modern technologies to local ones. They perceived agrochemicals as the best means to combat against pests and to increase rice production. Paddy farmers had weak perception towards intangible impacts of modern technologies on soil, water and environment. Therefore, to improve such perceptions it is recommended that extension should use special channel such as result demonstration fields, farmer field school, Radio and TV programs, field day and conducting visit to rice research station and low external input used farms. Because of the positive effect of extension participation on perception toward sustainable agriculture, extension needs to expand its coverage to access more farmers especially low educated and more aged and experienced farmers who are of the majority of farmers in the area of study to change and improve their perception towards sustainable agriculture. Also, farm infrastructure of a lot of paddy farmers should be prepared for diversification and rotation, as they need consolidation, integration and drainage.

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