Research Article
Socio Economic Determinants of the Adoption of Integrated Natural Resource Management Technologies by Small Scale Farmers: Evidence from Western Kenya

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Abstract: The main aim of the study was to examine the influence of socio economic factors on the adoption of Integrated Natural Resource Management (INRM) technologies that could restore soil fertility. INRM bridges the gap between high external input agriculture and extreme forms of traditional low external input agriculture. The main components of INRM in Ndhiwa division are chemical fertilizer, animal manure, green manure, stover lines and agro forestry. However the adoption of these technologies appears to be low resulting to probably the low production. It is not understood well why farmers who rely on agriculture for their livelihoods, either do not adopt or adopt the technologies and then abandon. An ex-post-facto survey design which utilized both qualitative and quantitative methods of data collection was used in the study. For quantitative data collection, a sample of 220 small scale farmers selected using systematic random sampling from the small scale farmers in the Division were engaged. For qualitative data, 40 small scale farmers and 37 Key Informants selected using purposive sampling from the division were used. Results of the study indicated that households education status, gender, access to credit and membership in social groups were important variables which had positively and significantly influenced adoption of INRM technologies. The overall finding of the study underlined the high importance of institutional support in the areas of extension, strengthening social groups and improving market and credit condition to enhance adoption of INRM technologies. The study will be significant to planners, policy makers, researchers, extension and farmers to build the case for interventions on INRM within the development sector for improved and sustainable agriculture and rural development.

Keywords: Adoption, integrated natural resource management technologies, small scale farmer

INTRODUCTION

The continued threat to the world's natural resources is exacerbated by the need to reduce poverty and unsustainable farming practices. A significant proportion of the rural population of Sub-Saharan Africa (SSA) is food insecure and malnourished. Food security is one of the main global concerns in many developing countries (Food and Agriculture Organization, 1987; International Federation of Agricultural Producers, 1996). Food insecurity is most acute in sub-Sahara Africa, where the attainment of food security is intrinsically linked with reversing stagnation and safeguarding the natural resource base (Vanleuw and Giller, 2006). Declining soil fertility and low nutrient levels is recognized as one of the major biophysical impediment to agricultural growth of African agriculture (Nye and Greenland, 1960; Food and Agriculture Organization, 1987; Pieri, 1989; Yates and Kiss, 1992; Vanleuw and Giller, 2006).

Recent estimates indicate that by the year 2020, the SSA annual cereal imports will rise to more than 30 million metric tons, as the per-capita food production continues to decline against a background of rapidly growing population estimated at 3% per annum. This failure to match food supply to demand is mainly attributed to soil nutrient depletion following intensification of land use without proper land management practices and inadequate external inputs (Sanchez et al., 2001). The low soil fertility arises due to:

- Breakdown of the erstwhile traditional natural fallow system that used to be the means of replenishing the soil fertility
- Continuously cultivation of crops without external fertilizer due to the high costs of mineral fertilizers

The need to improve soil management in the continent has become a very important issue in the development policy agenda because of the strong linkage between soil fertility and food insecurity on one hand and the implications on the economic wellbeing of the population on the other hand (Ajayi et al., 2003).

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Integrated Natural Resource Management is the management of soil fertility using multiple practices simultaneously in an integrated fashion in order to exploit the prospective complementarities among different soil management techniques. At the core of the Integrated Soil Fertility Management (ISFM) paradigm is the recognition that no single component of soil fertility management can stand on its own in meeting the requirements of sustainable soil fertility management (Vanlauwe, 2004; Place *et al.*, 2003).

The popularity of INRM based approaches to natural resource management in the USA is reflected in the rise of coast care, land care, regional bodies and other social mobilization approaches to INRM throughout the world. Soil fertility depletion and the corresponding declining agricultural productivity in the world have led to many attempts to develop and popularize INRM technologies that consequently restore soil fertility. INRM bridges the gap between high external input agriculture and extreme forms of traditional low external input agriculture. The main components of INRM practices are fertilizers, manure, improved fallows, agro forestry and green manures. INRM technology has the potential to improve soil fertility through the maintenance increase of soil organic matter and biological Nitrogen (N) fixation from nitrogen fixing tree species (Young, 1997).

Researchers in the USA have introduced INRM as a subsistence option to replenish soil fertility within the shortest possible time (Phiri *et al.*, 2003). Various studies in the world have shown the potential of INRM as an approach to sustainable agricultural production and soil management especially in the tropics. There are some technologies that replenish soil fertility and provide other needs such as fuel wood, hence become integral part of the household subsistence needs. INRM is a sustainable agricultural system with potentials to improve food security and is being promoted in most parts of the USA (Young, 1997). Despite the successes and the increased adoption of INRM in North and South America, the adoption among small scale farmers in Eastern and Southern Africa has been very low (Young, 1997).

In the Philippines, consideration efforts have been committed to research and extension to facilitate the adoption of the hedgerow intercropping, yet a recent report (Young, 1997) described adoption as "sporadic and transient, rarely continuing once external support is withdrawn". This report evaluates the cost-benefit of alternative forms of hedgerow intercropping. However, farmers were more interested in a local adaptation of the technology which includes natural vegetation and grass strips. Another disadvantage was the cost of credit and land tenure security which affects the farmer's

planning horizons and the confidence with which they expect to benefit from long term investment in soil conservation.

Smallholder agriculture in much of the low-income tropics is nonetheless characterized by widespread failure to make sufficient soil fertility replenishment and soil conservation investment in order to sustain the quality of farmland (Sanchez *et al.*, 2001; Reardon *et al.*, 2001; Barret *et al.*, 2002; World bank, 2003). A substantial literature based on cross-sectional analysis has explored the adoption of INRM methods in order to understand the failure to make these critical investments (Sheikh *et al.*, 2003; Phiri *et al.*, 2003; Franzel *et al.*, 2001; Pfister *et al.*, 2005). But there has been little accompanying exploration of the reasons for disadoption of these technologies, especially over a period of many years. Since INRM requires ongoing practice, it is essential to understand both initial adoption and continued application of the methods.

Land productivity in many parts of sub-Sahara Africa is declining (Vanlauwe, 2004; Place *et al.*, 2003). Crop yields for staple food crops such as maize, millet and sorghum oscillate at 1 tonne grain/ha in small holder rain fed farms in SSA. Furthermore, yield levels in SSA show no clear tendency of increasing over the last 2 generations (Vanlauwe, 2004; Place *et al.*, 2003).

The potentials of INRM as a means of building up soil productivity in the long run and thereby attaining higher yield at lower costs, has been fully acknowledged and picked up by commercial farmers in Zimbabwe and Tanzania operating in degradation sensitive farming landscapes (Place *et al.*, 2003; Vanlauwe, 2004). There are many examples of successful adoption of INRM technologies in Eastern and Southern Africa where crop yields have increased through INRM technologies.

Like in most Sub Sahara African countries, the major constraint to small holder farming in Kenya is the declining soil fertility (Smaling *et al.*, 1993). Small holder farms of about 2 ha on average are usually cultivated continuously without adequate replenishment of plant nutrients resulting in removal of nutrients from soils mainly through crop harvests. An average of maize grain crop yield of less than 500 kg/ha has been reported in Western Kenya (Odera *et al.*, 2000). For instance in Western Kenya, which has high population densities exceeding 300 per km^2, farms are characterized by widespread failure to make sufficient soil fertility replenishment investments, resulting in declining soil fertility, low returns to agricultural investment, decreased food security and general high food prices consequently threatening food security in this region (Odera *et al.*, 2000).

Ndhiwa is one of the 4 divisions of Ndhiwa distict in Western Kenya. Agronomic and soil science research in the recent years shows that soil nutrient mining, lack of soil conservation measures, mono-cropping and continuous cropping without external fertilizer is widespread in Western Kenya, undermining the ability of many agrarian households to produce enough food supplies for subsistence (Smaling *et al.*, 1993; Van der Bosch *et al.*, 1998; Tittonell, 2003; Food and Agriculture Organization, 2004). For instance, Smaling *et al.* (1993) report average annual net mining of 42 Kg nitrogen/ha, 3 Kg phosphorus/ha and 29 Kg potassium/ha from the soils in this region. Various Studies in the world have shown the potential of INRM as an approach to sustainable agricultural production and soil management especially in the tropics. There are some technologies that replenish soil fertility and provide other needs such as fuel wood, hence become integral part of the household subsistence needs. INRM is a sustainable agricultural system with potentials to improve food security and is being promoted in most parts of the world (Okuro *et al.*, 2002).

The main objective of this study was to examine the influence of socio economic factors on the adoption of integrated natural resource management technologies in Ndhiwa district. This study also provides a useful input for the development of training materials for extension staff that are critical in the transfer of agricultural technology. Besides, the study also provide insight into whether and how external assistance can be used more effectively to enable smallholder households to secure their basic needs, promote self-reliance and adopt sustainable INRM technologies as a means of breaking the cycle of natural resource degradation to ensure agricultural/environmental sustainability.

RESEARCH METHODOLOGY

The study area: The study was carried out in Ndhiwa Division of Ndhiwa District. It is one of the four divisions in Ndhiwa District, located in the southwestern part of Kenya along Lake Victoria. It is located between longitude 34^0 12' and 34^0 40' east and latitudes 0^0 28' and 0^0 40' south (Government of Kenya, 2001a). Ndhiwa is inhabited mainly by the Luo community. The division has a population of approximately 115, 122, with an annual growth of 2.7%. The division has a mean density of 270 persons/km^2 but the distribution within the division is influenced by the availability of road infrastructure and climate (Government of Kenya, 2001a). The female/male sex ratio is 100/110 with the youth and labor force comprising 23 and 47.8%, while the dependency ratio is 100:110. The Division is further sub divided into 4 locations and 11-sub-locations. It has a population of 43,231 small scale farmers (Government of Kenya, 2001a).

According to Jaetzold and Schmidt (1982), the division lies in lower midland (lm3) agro-ecological zone. It is situated at an altitude of 1200-1400 m above sea level. The mean rainfall is about 1300 mm received in a bimodal pattern. The Division has three types of soils; black cotton soil (vertisol), silt loam, clay loam (luvisoils) with drainage being poor in some of the soils (Jaetzold and Schmidt, 1982). Agriculture is the lifeline of the division's economy employing over 50% of the residents. Smallholder farming is the dominant land use practice accounting for about 86.8% of land cultivated in the division (Government of Kenya, 2001a). The cultivation of food crops is dominated by maize, sorghum and bean production (Government of Kenya, 2001a). The annual cereal production in 2000 was 41,520 tones as compared to its cereal demand of 41,819 tones. The map of the study area is shown in Fig. 1.

The high use of firewood and charcoal contributes to deteriorating tree and vegetation cover exposing the soil to severe degradation especially on hill tops, a trend that threatens future livelihood activities. Agronomic and soil science research in recent years has shown that soil nutrient mining, mono-cropping and continuous cropping is widespread in Ndhiwa division, undermining the ability of many agrarian households to produce enough food supplies for subsistence (Smaling *et al.*, 1993; Van der Bosch *et al.*, 1998; Tittonell, 2003; Food and Agriculture Organization, 2004). For instance, Smaling *et al.* (1993) report average annual net mining of 42 Kg nitrogen/ha, 3 Kg phosphorus/ha and 29 Kg potassium/ha from the soils in this region.

Sources of data: The study used both qualitative and quantitative data collection techniques. The data collection tools included.

Questionnaires: Questionnaires were administered to the first sub-category (220 small scale farmers) selected for the study. Questionnaires were considered ideal because of the ease of administration and scoring of the instrument besides the results being readily analyzed (Ary *et al.*, 1979). The items on the questionnaire were developed on the basis of the objectives of the study. The questionnaire captured data on the socio-demographic characteristics of the respondents, the degree of adoption of INRM technologies, socio-economic determinants of the adoption of INRM technologies, socio-cultural determinants of the adoption of INRM technologies and the institutional determinants of the adoption of INRM technologies.
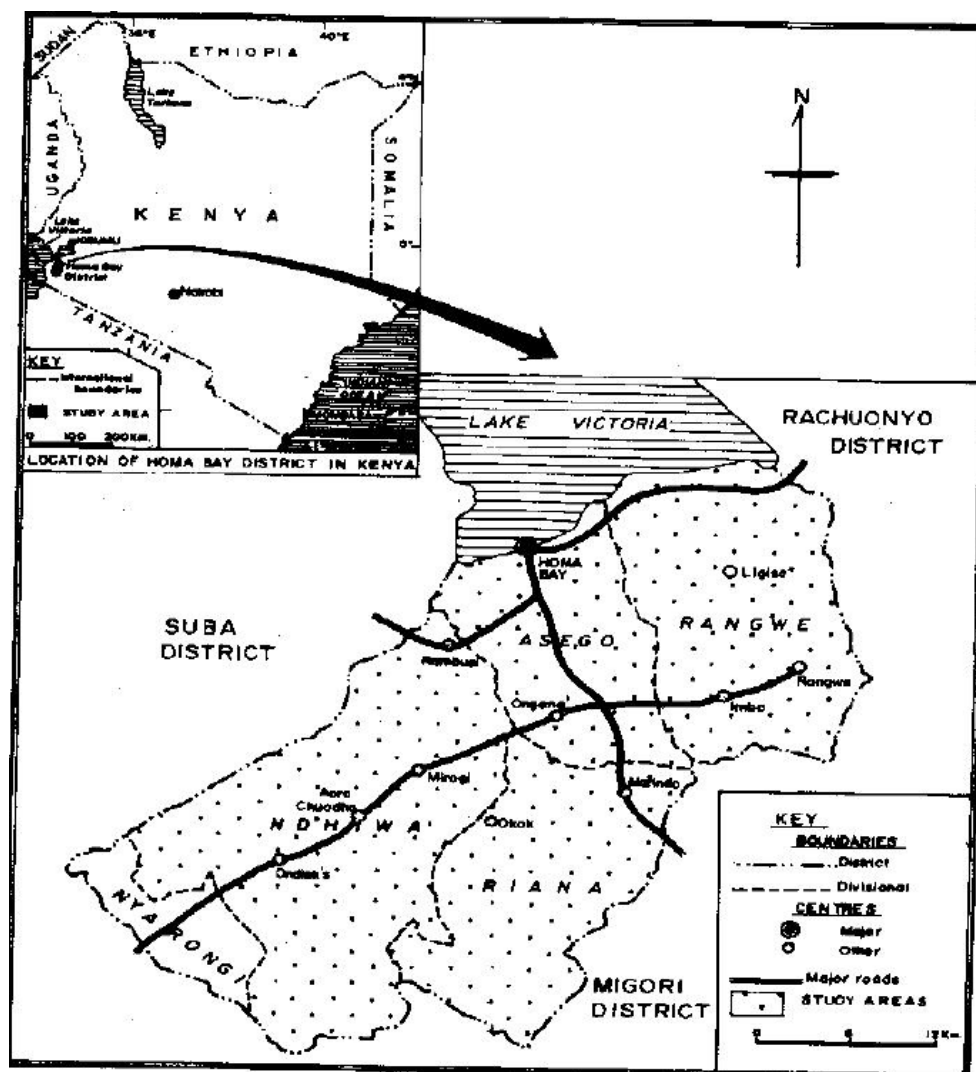
Fig. 1: Location map of the study area in Kenya

In-depth interviews: Semi-structured interview schedule guidelines with relevant questions were developed for the 37 key informants. The semi-structured interview schedule was considered appropriate for extension officers from the Ministry of Agriculture and opinion leaders because they have varied literacy levels. Some of them were not able to interpret and react to a questionnaire. Thus the semi-structured interview schedule was used to obtain in-depth information from the extension officers and opinion leaders regarding their opinion on the determinants of the adoption of improved NRM practices in Ndhiwa division.

Focus group discussion: Focus Group Discussion (FGD) guideline was developed for the 40 small scale farmers. A total of four FGDs were held. FGDs were important in obtaining information that could not be easily obtained through face-to-face interview or questionnaire. For this method, the researcher brought together forty small scale farmers in four groups, to discuss the topic. Atopic guide to aid discussion was prepared beforehand and a range of aspects of the topic will be explored. Brainstorming techniques were used to explore the topic.

Observations: To get a greater picture of INRM technologies, a checklist was developed for observations to be made. Data was collected by the researcher so that a detailed understanding of the values and beliefs held by the members of the population can be understood. Observations were done to gather

evidence about how value judgments made by extension staff and farmers impact on decision making. Observation were recorded as field notes and analyzed for content.

Sample size and sampling procedure: The sampling frame was a list of 43,231 small scale farmers from Ndhiwa District Development Offices for the respective division. The sample size was obtained using the coefficient of variation (Nassiuma, 2000). This is because for most surveys or experiment, a coefficient variation of at most 30% is usually acceptable. The study took a coefficient variation of 21% and a standard error of 0.02. The formula given by Nassiuma (2000) is:

$$n = \frac{NC^2}{C^2 + (N-1)\,e^2}$$

where,
n = Sample
N = Population
C = Covariance
e = Standard error

The number of households for Ndhiwa division will be:

$$n = \frac{43231 \times (21\%)^2}{(21\%)^2 + (43231)\,(0.02)^2} = 220 \text{ households}$$

The four locations of the small scale farmers was the criterion for stratified proportionate random sampling. All the small scale farmers in the four locations were used to enable random selection of households to be included in the study. A systematic random sampling procedure was used to select the number of households in each stratum. Purposive sampling technique was applied to identify individuals to participate in the focus group discussion and Key informants to be interviewed. A total of 40 small scale farmers were purposively selected to participate in the four FGDs.

From each location, three categories of target group, viz the small scale farmers, Ministry of Agriculture Officers and opinion leaders were targeted. Among the Ministry of Agriculture target category, one Divisional Agriculture Extension Officer, five subject matter specialists from Ndhiwa division and one location Agricultural Extension Officer from each location yielding a total of seventeen Ministry of Agriculture officers. From the third category of opinion leaders (1 Do, 4 chiefs, 11 assistant chiefs and 4

Table 1: Sampling by location in Ndhiwa division, Ndhiwa district

Locations	Farmers	Population	Sample
North Kanyamwa	9880	0.24	50
South Kanyamwa	12700	0.30	65
Central Kanyamwa	8700	0.21	45
West Kanyamwa	11751	0.28	60
Total	43231	1.00	220

councilors) were selected yielding twenty opinion leaders. They supplemented the information from the small scale farmers. The entire sampling matrix yielded a total sample size of 297 for the proposed study. The sampling by location of small scale farmers in Ndhiwa division is shown in Table 1.

DATA ANALYSIS

All the data collected from the study area as in the questionnaires, FGDs, in depth interviews and observation reports were analyzed in an ongoing process. Quantitative data was processed, coded and analyzed using computer statistical packages (S.P.S.S version 13). The results were presented by use of descriptive statistics, namely percentages and frequencies. Qualitative data will be transcribed and subsequently themes and sub-themes derived. The themes and subthemes were then presented as they emerged.

Ethical consideration: The study was conducted in accordance with the standard research ethics. Informed consent was sought prior to data collection. Anonymity and confidentiality was also upheld. An appointment for administration of questionnaires to the respondents was prepared with the assistance of the village headmen. The principal researcher guided and supervised the fieldstudy during data collection. The instruments were then administered to household heads to collect the required data in face-to-face interview and their responses recorded accordingly.

Definition of variables:
Dependent variable: The dependent variable in this study was adoption index which indicated the degree of adoption of INRM technology package. Degree of adoption in this case was a continuous dependent variable. The degree of adoption refers to farmers' level of use of INRM technologies.

Independent (explanatory) variable: The independent variables of importance in this study are those variables, which are thought to have influence on the degree of adoption INRM technologies. These include households' personal and demographic variables and socio-economic variables. These explanatory variables are defined as follows:

Table 2: Summary of explanatory variables

Variable	Variable code	Operational definition of the variable
Access to credit	Credit	A dummy variable, with value 1, if a person has access to credit and 0 otherwise
Access to market	Market	A dummy variable, with value 1, if a person has access to market and 0 otherwise
Farmers age	Age	Rational number
Farming experience	Farexp	A continuous variable measured by years of experience
Sex, HH	Sex	A dummy variable with value 1 if the household is male and 0 otherwise
Labor availability	Labor	A continuous variable measured by man equivalent of the family labor
Off farm income	Offinco	A dummy variable with the value 1 if the household members engage in off-farm employment and 0 otherwise
Land size	Landsz	Land size owned in hectares
Access to inputs	Inputs	A dummy variable, with value 1, if a person has access to inputs and 0 otherwise
Membership in social groups	Memsg	Is measured as farmers' membership in social groups for the last 1 year

RESULTS AND DISCUSSION

Adoption of integrated natural resource management technologies: The study focused on four INRM technologies. These were the use of stover/trash lines for nutrient recycling, agro forestry for nutrient replenishment using woody species, use of livestock manure and use of inorganic chemical fertilizers. Stover (trash/lines are heaps of stover and other biodegradable crop detritus and farm (and off-farm) plant debris that the farmer places across the plot contour (s). To determine the level of adoption of INRM technologies farmers were asked to respond to a set of ten questions on degree of adoption of INRM technologies. The questions were based on use of fertilizer and manure, agro forestry and stover lines. The results obtained indicated that out of the 210 respondents 55 farmers (54.2%) used manure, 22 farmers (21%) practiced agro forestry and 10 farmers (9.5%) had stover lines in their farms while 16 farmers (15.3%) used fertilizer. On the other hand the remaining 115 (52.3%) had not adopted any of these technologies. Table 2 presents results of how farmers adopted INRM technologies.

From the Table 3, it was noted that out of the four INRM technologies studied, it was only the use of manure that could be judged as the most significantly adopted by the respondents, where (54.2%) of the respondents had fully adopted the practice. It is to be recognized that all the respondents were aware and interested to use manure but not all did. The respondents indicated that even though they were interested in using manure, the technology was not always available and when it became available, it was limited in quantity and consequently, it would not within the reach of most poor rural farmers.

The use of fertilizer was also known to all (100%) of the respondents while only a few (15.3%) of the respondent respondents eventually adopted the technology. It was noted here that the non-significant adoption of this technology could be attributed to non-ready availability of the fertilizer and lack of affordability on the part of the respondents due to high

Table 3: Adoption of INRM technologies

Technology	Frequency	(%)
Manure use	55	54.2
Stover lines	10	9.5
Agro forestry	22	21
Fertilizer use	16	15.3
Total	105	100

cost. During group discussion most farmers expressed that none of them had used fertilizer and stover lines.

Similar reasons were adduced for non-significant use of agro forestry where only 10% respondents adopted and as majority were aware of the technology. The table also shows that the use of stover lines was only adopted by 10 (9.5%) respondents. This indicates low adoption rates for these technologies. All the practices as a complete package were adopted by only 11.9% of the respondents. It was observed that in all the INRM technologies studied, the respondents were more aware, interested and tried them than they adopted them. This goes to prove that awareness of technology, interest in it and even trial do not automatically guarantee adoption. There could be other factors that interfere with adoption of these technologies.

Farmer's interest in adopting new practices may be constrained by inadequate information about that particular innovation, which may in part be caused by inability of the extension personnel to reach the farmers. It has been reported that most farmers stick to old practices as result of economic inability on the part of the farmers to afford the cost of innovations, risk involved, ignorance of existence of innovations and their attitude (Wasula, 2000). Non adoption of some of these technologies could be as a result of high prices, relative scarcity and poor presentation of the technologies to farmers, unavailability of the technologies and inability of extension agents to facilitate their adoption.

During focus group discussion farmers pointed out that, use of stover lines in the field is impossible due to its additional labor and time requirement. They also pointed out that fertilizer was expensive and hence low adoption of this.

Table 4: Age distribution of the farmers

Age group	Adopters (n = 105)	Non-adopters (n = 115)
Below 20 years	4 (3.8%)	2 (1.7%)
21-30	20 (19%)	30 (26%)
31-40	45 (42.9%)	55 (48%)
41-50	28 (26.6%)	20 (17.4%)
Above 50 years	8 (7.6%)	8 (7%)
Total	105 (100%)	115 (100%)

Table 5: Sex distribution of farmers

Gender	Adopters (n = 105)	Non-adopters (n = 115)
Male	65 (61.9%)	31 (30%)
Female	40 (38.1%)	84 (70%)
Total	105 (100%)	115 (100%)

Key informants from the sampled institutions cited the rising cost of the rising cost of fertilizer and tree seedlings as a major budgetary constraint. "Everything is going up in price, even fertilizer and tree seedlings are very expensive these days". Similarly, key informants from the sampled institutions cited additional labor and time requirement for use of stover lines in the farms.

FGD results also indicated that people are aware of the technologies like fertilizer and agro forestry but such technologies are priced out of their reach. Even in relatively better off regions only a few participants said they use fertilizer and agro forestry. A woman FGD participant from one cluster said "we long to use fertilizer but we cannot afford". In some cases FGD participants expressed awareness of the INRM technologies but cited lack of information on whether such technologies are affordable or easily accessible.

Demographic and socio-economic characteristics: In order to understand the sample households, it is very important to describe their demographic characteristics. The farmers were selected from the four locations in Ndhiwa. The farmers were asked to respond to respond to a set of questions on the socio-economic factors that have influence on the adoption of INRM technologies. The factors included gender, age and level of education, size of household, income and farm size and off-farm income.

Age distribution of farmers: The role of age in explaining technology adoption is somewhat controversial. It is usually considered in adoption studies with the assumption that older people have more farming experience that helps them to adopt new technologies. On the other side, because of risk averting nature of older age farmers are more conservative than the youngest one to adopt new technology. The risk of adopting INRM technologies arises from the high cost of production. Due to this fact age was thought to have a negative relationship with the adoption of INRM technologies.

The farmers were asked to indicate the category of their age. Forty five out of one hundred and five adopters (42.9%) interviewed indicated that they were between the ages of 31-40 years. Table 4 presents the frequencies and percentages of age group of the farmers interviewed.

As shown above, forty five out of one hundred and five adopters (42.9%) interviewed indicated that they were between the ages of 31-40 years. This is a prime age when the farmers are very active and ready to risk by adopting technologies delivered to them. Farmers who are within age group 18-43 years tend to be more active in practical, "hands-on" activity as compared to older farmers. The results reveal that older farmers are less likely to adopt INRM technologies in question.

Moreover, younger farmers may incur lower switching costs in implementing new practices since they only have limited experience and the learning and adjusting costs involved in adopting INRM technologies may be lower for them. This study therefore found out that farmers who are young were better adopters than old farmers. Rogers (2003) argued that younger and educated farmers are more inclined to adopt new practices. This was supported by Wasula (2000), who found that the age of a household had significantly influence the adoption of contour vegetative strips. This raises an important extension policy issue. Extension systems must differentiate their clientele based on critical characteristics such as age.

Sex distribution of farmers: Gender difference is found to be one of the factors influencing adoption of new technologies. Due to many socio-cultural values and norms males have freedom of mobility and participation in different meetings and consequently have greater access to information. Therefore, sex was hypothesized to influence adoption in favor of farmers.

More than half of the farmers interviewed (56%) were female compared to 44% being male. Table 5 presents the gender distribution of the farmers interviewed.

Table 5 reveals that out of 220 farmers interviewed 124 farmers (56%) were female compared to 96 farmers (44%) who were female. However male farmers were more likely to adopt INRM technologies than female farmers. This is in agreement with (Phiri *et al.*, 2003), in his study found that proportionately more men planted improved fallow than women primarily because married women need consent of their husbands before planting trees.

In sub-Saharan Africa, conventional methods of agricultural extension have traditionally tended to be geared towards men while ignoring women (Saito *et al.*,

1994). The authors noted that the bias against women is manifested in the delivery of the extension message itself. The message is generally provided by male extension agents to men with implicit assumption that it will "trickle down" to women.

The authors also noted that extension messages tend to focus on activities of male farmers while ignoring the wide range of agricultural activities, responsibilities and constraints facing women farmers. They pointed out that discrimination against women in agricultural technology generation and dissemination inevitably affected women negatively, leads to inefficient use of resources (as women fail to adopt improved technologies) and lower levels of agricultural production.

Previous research in Africa has documented women's lesser access to critical resources (land, cash and labor) often undermining their ability to mobilize labor needed to carry out labor-intensive INRM technologies (Quisumbing *et al.*, 1995). These inequalities are caused by cultural conditions in many African societies which traditionally did not grant women secure entitlements to land and other property (Quisumbing *et al.*, 1995).

This shows that gender was related to adoption of INRM technologies which concurs with Oywaya's findings (1995) who found significant differences in adoption between the male headed households and female headed households in Machakos, Kenya. Research and extension organizations will need to compensate for this by making extra effort to reach women, who are generally disadvantaged by skewed patterns of endowments of critical resources needed to make INRM technology adoption remunerative. Making female farmers targets in extension therefore, makes sense for agricultural and rural development.

The general perception is that due to cultural beliefs, women may have little decision making authority in farming (Ani, 2002). Among the challenges faced by women are permission to attend training, household responsibilities, particularly young children; lack of tools; and poor health. Understanding and addressing these issues is essential if women are to be included in any type of outreach or developmental program. Field observations and confirmation through key informants revealed that this is true even in the present day and age.

During FGD farmers pointed out that, beliefs, cultural attitudes and social norms such s trees and land belong to the men were deterrent to adoption to the adoption of INRM technologies by women farmers. Findings from the key informant interviews also indicated that land and trees belong to men hence women farmers had no incentive to conserve the soil leading to low adoption of INRM technologies.

Table 6: Level of education of the farmers

Age group	Adopters (n = 105)	Non-adopters (n = 115)
None	5 (4.8%)	10 (8.7%)
Lower primary	26 (25%)	33 (28.7%)
Upper primary	45 (43%)	53 (46.1%)
Secondary school	28 (20%)	15 (13%)
Tertiary	9 (7%)	4 (3.5%)
Total	105 (100%)	115 (100%)

Level of education of farmers: Education is very important for the farmers to understand and interpret the agricultural information coming to them from any direction. A better educated farmer can easily understand and interpret the information transferred to them by development agent. Farmers were asked to indicate the highest level of education they attained. Table 6 presents the frequencies and percentages of the level of education of the farmers.

Forty-five out of one hundred and five adopters interviewed (43%) had at least upper primary level of education and 26 farmers (25%) had lower primary school level of education. Those with secondary level of education and above were 37 (27%). INRM technologies are knowledge intensive and require considerable management input (Barret *et al.*, 2002). Formal schooling may enhance or at least signify latent managerial ability and greater cognitive capacity. This is in agreement with Amudavi (1993), Chitere and Doorne (1985) and Wasula (2000) who in their respective studies found that education is a significant factor in facilitating awareness and adoption of agricultural technologies.

Education enables one to access information needed to make a decision to use an innovation and practice a new technology. High level of education enhances the understanding of instruction given and also improves the farmers' level of participation in agricultural activities. The implication is that extension systems and agricultural development projects in this region should seek not only to provide technical options to small scale farmers, but also to attempt to make up for low levels of educational attainment, perhaps through emphasis on management training and skill building.

Gross monthly farm income of farmers: Farm income is the main source of capital to purchase farm inputs and other household consumable goods. Farm income refers to the total annual earnings of the family from sale of agricultural produce after meeting daily family requirements. In this study farm income was estimated based on the sales of crop produce, livestock and livestock products. The major cash income for sample farmers in the study area was from sale of crops.

Table 7: Approximate level of gross monthly farm incomes of the farmers

Monthly farm income	Adopters (n = 105)	Non-adopters (n = 115)
<3,000	46 (44%)	53 (46%)
3,001-6,000	50 (47%)	50 (43%)
6,001-10,000	7 (7%)	10 (9%)
>10,001	2 (2%)	2 (2%)
Total	105 (100%)	115 (100%)

Table 8: Approximate land owned by the farmers

Land in HA	Adopters (n = 105)	Non-adopters (n = 115)
4-5	6 (5.7%)	4 (3.5%)
3-4	8 (7.6%)	7 (6.1%)
2-3	22 (21%)	20 (17.4%)
1-2	27 (25.75%)	26 (22.6%)
>1	42 (40%)	58 (50.4%)
Total	105 (100%)	115 (100%)

Table 9: Number of members in farmers' households

No in household	Adopters (n = 105)	Non-adopters (n = 115)
>10	20 (19%)	16 (13.9%)
8-10	22 (21%)	20 (17.4%)
6-8	24 (22.0%)	20 (17.4%)
4-6	18 (17.1%)	22 (19.1%)
2-4	15 (14.3%)	26 (22.6%)
>2	6 (5.7%)	11 (9.6%)
Total	105 (100%)	115 (100%)

More than half of the adopters (91%) indicated that they get less than Kshs 6,000 as gross income. Nine out of one hundred and five (9%) indicated that their gross monthly income was between Kshs 6,000 and 10,000. Table 7 presents the levels of gross monthly income of farmers.

Household farm income can be used as a proxy to studying capital because it determines the available capital for investment in the adoption of technologies and it is a means through which the effect of poverty can be assessed. According to World Bank (2003), poverty is the main cause of environmental degradation. One way of measuring the household's poverty is through income. Household income has a big bearing on the socio-economic status of farmers. Farmers from higher economic status have access to resources and institutions controlling resources necessary for the effective adoption of technology (World Bank, 2003). This is consistent with the findings of Wasula (2000), who found that farm income had a significant relationship with the adoption of soil conservation measures.

Farm size: Land is the main asset of farmers in the study area. Farmers in the study area use both their own land and also rent farm for crop production. More than half of the adopters (65.7%) indicated that they owned less than 2 ha. Fourteen out of one hundred and five (13.3%) indicated that owned between 3 and 5 ha. Table 8 presents the average size of land owned by farmers.

The probability of adopting INRM technologies was positively and statistically influenced by the total farm size operated by a farmer. The policy lesson for research and extension is that INRM technology development must emphasize not only sufficient divisibility but also that new methods prove remunerative even at small scale operation.

Family size: Family size in the study is considered as the number of individuals who reside in the farmers' household. Large family size assumed is assumed as an indicator of labor availability in the family. Based on this fact this variable was hypothesized to have positive and significant relationship with adoption of INRM technologies. Sixty six (62.9%) out of one hundred and five adopters indicated that they had more than six members in their families. Thirty nine out of one hundred and five (39.1%) indicated that they had less six members in their households. Table 9 presents the average size of the households

The number of members per family was significant and positively associated with adoption of INRM technologies. This would seem to reflect the important role that availability of family labor (number of adults in the household) plays in the adoption of these practices. Family labor assumes great importance given that low incomes constraints financial liquidity for hiring wage laborers and given possible moral hazard problems associated with non-family labor calling for considerable supervision. Given that the bulk of labor for most farm operations in this region is provided by the family rather than hired, lack of adequate family labor accompanied by inability to hire labor can seriously constraint adoption of INRM technologies.

Off-farm income: In most part of rural Kenya, off-farm employment is viewed as transitory situation and only considered necessary as income source for low earning farm community. In this study area, grain trading, vegetable trading, teaching and daily labor were found to be some of the off-farm activities in which sample households were participating. Hence those households who have got an engagement in off-farm employment are understood to raise their annual income. Therefore, in this study, it was hypothesized that there is appositive correlation between participation in off-farm activities and the adoption of INRM technologies.

As illustrated in Table 10, more than half of the adopters (91%) indicated that they get less than Kshs 5,000 as gross off-farm income. Nine out of one hundred and five (9%) indicated that their gross monthly income was between Kshs 5,000 and 8,000. Participation in off-farm activities had significant relationship with adoption of INRM technologies.

Household's off-farm income can be used as a proxy to studying capital because it determines the

Table 10: Approximate level of monthly off-farm incomes of the farmers

Monthly off-farm income	Adopters (n = 105)	Non-adopters (n = 115)
<1,000	46 (44%)	53 (46%)
2,001-4,000	50 (47%)	50 (43%)
5,001-8,000	7 (7%)	10 (9%)
>8,001	2 (2%)	2 (2%)
Total	105 (100%)	115 (100%)

Table 11: Approximate farming experience of farmers

Farming experience	Adopters (n = 105)	Non-adopters (n = 115)
<3	46 (44%)	53 (46%)
3-6	50 (47%)	50 (43%)
6-10	7 (7%)	10 (9%)
>10	2 (2%)	2 (2%)
Total	105 (100%)	115 (100%)

Table 12: Land ownership status by farmers

Monthly income	Adopters (n = 105)	Non-adopters (n = 115)
Communal	18 (17.1%)	30 (26.1%)
Private	84 (80%)	85 (73.9%)
Rented	3 (2.9%)	0 (0%)
Total	105 (100%)	115 (100%)

available capital for investment in the adoption of technologies and it is a means through which the effect of poverty can be assessed. According to World Bank (2003), poverty is the main cause of environmental degradation. One way of measuring the household's poverty is through income. Household income has a big bearing on the socio-economic status of farmers. Farmers from higher economic status have access to resources and institutions controlling resources necessary for the effective adoption of technology (World Bank, 2003). This is consistent with the findings of Wasula (2000), who found that farm income had a significant relationship with the adoption of soil conservation measures.

Off-farm income from informal and formal non-agricultural employment proved quite important in fostering adoption of INRM technologies. Majority of the farmer did not have off-farm income hence the low adoption. Cash is essential in the hiring of labor for the construction and maintenance stover/trash lines or for planting agro forestry trees, as well as for purchase of chemical fertilizer. At existing productivity levels and production scales, the high-population-density small farm system of Western Kenya might not be generating sufficient investible surplus to remain self-sustaining in the absence of non-farm income to invest in sustainable agricultural intensification, including INRM technologies (Marenya *et al*., 2003).

Farming experience: Experience of the farmer is likely to have a range of influences on adoption. Experience will improve farmers' skill at production. A more experienced farmer may have a lower level of uncertainty about the innovation's performance. Farmers with higher experience appear to have often full information and better knowledge and are able to evaluate the advantage of the technology considered. Therefore, it was hypothesized that farming experience has a positive influence on adoption of INRM technologies.

More than half of the adopters (91%) indicated that they had 6 years farming experience. Nine out of one hundred and five (9%) indicated that their framing experience was between 6 and 10. Table 11 presents the levels of farming experience of farmers.

As depicted in Table 12 the results of this study is in contrast to the assumption, where farming experience was expected to have positive relationship to the adoption of INRM technologies. The result shows that there is no relationship between farming experience with adoption of INRM technologies. The result is in line with the findings of Rahmeto (2007) and Chilot (1994). Ani (1998) and Iheanacho (2000) also indicated that farming experience of farmers to a large extent affects their managerial know-how and decision making. Besides, it influences the farmers' understanding of climatic and weather conditions as well as socio-economic policies and factors affecting farming.

Land tenure: Land tenure provides farmers with full rights of land ownership and usage thus influencing the decision to participate in natural resource management. Land ownership with title deeds accords the farmers the right to usage (security of tenure) thus creating an incentive to farmers to adopt new, long term and even riskier technologies.

Table 12 shows that a significant majority (80%) of the adopters owned land privately but the adoption of these technologies was still low. Only a minority (2.9%) rented land. These findings agree with those found by Wasula (2000) where land ownership did not seem to have a significant effect on the adoption of agro forestry related technologies in Njoro and Rongai divisions, Kenya. According to Wasula (2000) what seemed important was how farmers feel about their property with or without the land ownership.

Access to credit: Adoption of INRM technologies by farmers is motivated by the income gained from the sale of the produce. Farmers grow crops not for consumption purpose only but to fetch cash income which is allocated for purchasing farm inputs and meet other family needs. But constraints to adoption of INRM technologies are numerous: the cost of fertilizer, high labor requirement and technical skill need for INRM technologies management, are some of the constraints that hinder the adoption of this technologies.

Farmers without cash and no access to credit will find it very difficult to adopt new technologies.

Table 13: Access to credit by farmers

Use of credit	Adopters (n = 105)	Non-adopters (n = 115)
Yes	19 (18.1%)	10 (8.7%)
No	86 (81.9%)	105 (91.3%)
Total	105 (100%)	115 (100%)

Table 14: Access to inputs by farmers

Access to inputs	Adopters (n = 105)	Non-adopters (n = 115)
Yes	25 (23.8%)	10 (8.7%)
No	80 (76.2%)	105 (91.3%)
Total	105 (100%)	115 (100%)

Table 15: Access to market by farmers

Access to market	Adopters (n = 105)	Non-adopters (n = 115)
Subsistence	77 (73.3%)	86 (73.9%)
Commercial	28 (26.7%)	30 (26.1%)
Total	105 (100%)	115 (100%)

Previous authors verified this preposition (Legesse, 1992; Teressa, 1997). It is expected that access to credit will increase the probability of adopting INRM technologies.

According to Table 13, eighty six (81.9%) out of 105 adopters had not used credit as compared to nineteen (18.1%). This could have been the reason for the low adoption of the technologies. This showed that there was a significant relationship between access to credit and adoption of INRM technologies. This finding concurs with Ascroft (1973) where only 5% of the progressive farmers obtained loans.

This is disadvantageous to farmers who operate on a small scale level and are less influential to the credit sector. Poor credit conditions may also be another reason that suppresses the capacity to adopt an innovation. Although credit may appear quite rational to a farmer, social forces outside his control dictate his propensity to adopt the technology. The optimal effective INRM technologies require cash for labor that is used in constructing stover/trash lines, planting trees and purchase of chemical fertilizer. Credit therefore is a strong facilitator in enhancing effective access to INRM technology.

Access to quality inputs: Input delivered by an institution will have its own impact on adoption of a given technology and production and productivity of crops. With this understanding data on problems of input delivered by organizations and purchased from market were collected and summarized as in Table 14.

According to Table 14, eighty (76.2%) out of 105 adopters had not used quality inputs as compared to twenty five (23.8%). This could have been the reason for the low adoption of the technologies. This showed that there was a significant relationship between access to credit and adoption of INRM technologies. This finding concurs with Ascroft (1973) where only 5% of the progressive farmers obtained inputs from reputable

source. This is disadvantageous to farmers who operate on a small scale level and are less influential to the input and credit sector.

Poor input sources may also be another reason that suppresses the capacity to adopt an innovation. Although inputs from reputable source may appear quite rational to a farmer, social forces outside his control dictate his propensity to adopt the technology. The optimal effective INRM technologies require inputs from reputable sources. Inputs therefore are a strong facilitator in enhancing effective access to INRM technology. Focus group discussion reported delay and poor quality seedlings and expensive fertilizer as problems of accessing inputs by farmers. Key informants also reported increasing trend on seedlings, labor and fertilizer price.

Access to market: Markets are common centers both for producers, consumers and traders.

Table 15 shows that a significant majority (73.3%) of the adopters utilized their farm produce for subsistence. Beside the distance taken to travel from home to the nearest market was an average of 10 km. For sample respondents the minimum and maximum distance that a farmer had to travel to access market center were 2 and 30 km, respectively. This means that they could not access the market easily. Only a minority (26.7%) used their produce for commercial purposes. These findings agree with those found by Ascroft (1973) where only 8% of the less progress farmers had access to the market. The lack of market information represents a significant impediment to market access especially for small holders' produce. It substantially increases transaction costs and reduces market efficiency (Mwale, 1998). These findings also agree with Rahmeto (2007) who found that market disadvantaged small, less educated and less influential farmers.

Membership in social groups: Usually participation in the community development activities is perceived as willingness of a person to study together. The relationship between membership in social group and adoption is associated with interpersonal net-studying and exchanges between adaptors and non-adaptors of technology.

In this study membership in social group is hypothesized as involvement of the respondents in any informal and formal organizations as a member. Farmers who are members of any local organization are more likely to be aware of new information and practices. Therefore, it was expected that there would be positive and significant relationship between membership in social group and the adoption of INRM technologies.

Table 16: Farmer's membership in social groups

Social group	Adopters (n = 105)	Non-adopters (n = 115)
Input supply	10 (9.5%)	2 (1.7%)
Marketing	6 (5.7%)	2 (1.7%)
Co-operatives	2 (1.9%)	1 (0.9%)
Youth groups	6 (5.7%)	4 (3.5%)
Women groups	18 (17.2%)	16 (13.9%)
CBOs	10 (9.5%)	7 (6.1%)
None	53 (50.5%)	83 (72.2%)
Total	105 (100%)	115 (100%)

According to Table 16, fifty three (50.5%) out of 105 adopters were not members of any social group as compared to twenty five (49.5%). This could have been the reason for the low adoption of the technologies. This showed that there was a significant relationship between membership in social group and adoption of INRM technologies. According to Blackburn *et al.* (1982), participation in social groups is important because it indicates the extent of contact, which farmers have with organized groups and other public services and mass media. Groups provide forum for improving dialogue among farmers, thereby providing opportunity for efficient ways of ascertaining consensus on opinion about the relevance of technologies being presented to them (Norman *et al.*, 1989).

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Summary: This study was set to investigate the determinants of the adoption of INRM technologies by small scale farmers in Kenya's Ndhiwa division. The study was necessary because the performance of the agricultural sector has remained low even after the introduction of INRM technologies. The low adoption levels of these technologies affect the overall production of crops in the area. The study employed cross sectional survey design with an ex-post-facto approach. Data was collected from a sample of 220 farmers from different locations in the area.

The variations in adoption of the package practices among farmers were assessed from the point of view of various factors which influence farmers' adoption behavior. These influencing factors are categorized as social and economic, personal and demographic, institutional and socio-cultural factors. Most of the variables assumed to influence the adoption behavior were significantly associated with the adoption and degree of adoption of INRM technologies.

Results of data analysis indicated that more than half (56%) of the farmers interviewed were female as compared to (44%) being male. This is an indication that more women practice agriculture on a day-to-day basis compared to men. However the adoption INRM technology by women was lower than men.

Majority of the respondents were young farmers in the ages between 31- 40 years. On the education level most farmers were found to be literate. Adoption of manure use was better than the adoption of agro forestry, fertilizer use and use of stoverlines though the adoption of all these remained low.

Among the personal and demographic factors the study confirmed that education status household size and sex of the farmer were significantly related to the degree of adoption of INRM technologies. This implies that male farmers were advantaged and given more attention for INRM technologies as compared to female counterparts.

In the case of socio-economic variables household income, farm size, family size, off-farm income, frequency of contact with extension agent, attending training, access to market, availability of inputs and access to credit were also found to have positive and significant relationship with adoption of INRM technologies. This indicates that implementing the components of INRM technologies package as per recommendation by researchers is relatively complex as compared to other technologies. This is paramount to boost the adoption of INRM technologies and improve crop yields.

Conclusions: In view of the data analysis and results shown in chapter four it can be concluded as follows:

- Close to 47% of the farmers in the study area had adopted INRM technologies while close to 52% of the farmers had not adopted INRM technologies? This was low given that the technologies have been in existence for more than 3 years.
- The study further concludes that there were more youthful and female farmers. Since sex and age influenced adoption of INRM technologies, strategies should be developed so as to target more women groups and youth groups for increased production.
- Farmers education level does influence the use of INRM technologies and therefore it is related to the adoption of INRM technologies, a finding which concurs with studies cite earlier. It requires that farmers that farmers are educated on new technologies governing the crops production.
- Regarding adoption of the INRM technologies in relation to selected variables, a number of factors showed varying relationship. For instance tenancy status seemed not to influence farmer's adoption of INRM technologies while sex, level of education, income, farm size, family size, off-farm income, access to extension, membership of social groups, access to inputs, access to credit and market,

cultural traditions, beliefs and social norms seemed to influence the farmers adoption of INRM technologies in the study area.

- Farmers mentioned a number of constraints that act as deterrents to adoption of INRM technologies. These include: Cultural beliefs, cultural traditions, social norms, lack of awareness of awareness of INRM technology information, lack of where to secure inputs, high cost of inputs and market. Low level of frequency of extension contacts with farmers was also a common problem, which hindered faster rate of adoption. Others (Amudavi, 1993) have also cited these problems.

- The most dramatic change that will influence adoption of INRM technologies is the development of institutional strategies that target small-scale farmers so that potential adopters can adopt the INRM technologies to improve production.

- As compared to other technologies in agriculture INRM technologies require a little bit more skill to implement the package practice in their field. Therefore sufficient number of training, field day and demonstrations are of paramount importance to equip farmers with INRM skill. That is why the explanatory variable, education was having a strong relationship with probability and intensity of adoption of INRM technologies in this study. This fact shows that the current extension service delivered to small scale farmers has to change the past trends and special emphasis on skill training on INRM technologies as well as market extension aspects.

- The findings of this study revealed that the main difference in degree of adoption of INRM technologies was also related to access to credit and inputs and membership in groups. Because of this those sample small scale farmers who did not have access to credit and inputs did not adopt the technologies. So that provision of credit for all and arranging field day visit and tour program within certain period of time in the production season will be very much important to farmers to adopt new technologies.

- Being a member of a social group was also positively and significantly related with adoption of INRM technologies. Member of a group has got credit, seed and fertilizer supply from the group. Therefore, strengthening and expansion of social groups is one means to enhance adoption of INRM technologies in the area.

- The major constraint of INRM in the study area was the absence reliable seed supply and inputs.

Majority of adopter sample farmers purchased seed from individual seed growers. In line with this the sample farmers complained of seed quality they purchased and lack of inputs. The farmers further commented that, the seed purchased from the individual producer is by far better than the seed they purchased from the open market in quality wise.

- One of the major problems to the development of INRM technologies is poor marketing system. From the result of this study, it was realized that farmers were not in a position to obtain better income due to low selling price related to so many factors such as poor bargaining power of farmers. Therefore, much emphasis has to be given to improvement of marketing system particularly through cooperative unions. These cooperative unions should have to create reliable market price by communicating with other cooperatives found outside their localities.

- The other problem in the study area is unplanned production of crops. Almost all farmers found in the study area plant crops and trees crops in the same planting dates. The excess amount of harvest reaches at the same time and this situation creates favorable condition for middle men to set low price on the harvest. Therefore the extension service sector has to take in to consideration this issue and training is needed for farmers to stagger the planting time. Staggering the planting time will lead to extended supply of produce in the market and keep up the market price.

Recommendations: The following recommendations have been suggested from the findings and conclusions of the study:

- Extension agents should consider improving their level of participation in joint activities. They should also consider improving the number of visits to farmer's field to understand the farmers' conditions better.

- Plenty of extension effort is needed in dissemination of INRM technologies information. This effort could be in terms of field days, farm visits, agricultural shows, holding demonstrations that focus on new technologies.

- Ways and means of encouraging small-scale farmers to adopt INRM technologies without necessarily relying on government subsidies should be developed by encouraging them to form small groups with revolving funds.

- Researchers should encourage multistage development of technologies that favor small-scale farmers since they form a large proportion of farmers in Kenya today.
- Policy makers should provide small credit to farmers to help them meet the cost of adoption of INRM technologies. Such credits will go to purchasing of seeds, fertilizer and chemicals which are very expensive.
- Institutional strategies should be developed to favor young and women farmers since they are the majority who engage in agricultural activities on the ground.
- Farmers should be encouraged to form groups so that they can access credit and bargain for prices of their commodities.
- Farmers should be sensitized on socio-economic aspects that hinder adoption of technologies in the division.
- Producers and extension agents need adequate skills in production management practices starting from seed selection to post harvest technologies suitable at their level. Marketing principles, bargaining skills, business planning, quality management and post-harvest handling of agricultural products are some of the interventions needed in the study area.

REFERENCES

Ajayi, O.C., S. Franzel, E. Kuntashula and F. Kwesiga, 2003. Adoption of improved fallows technology for soil fertility management in Zambia. Empirical studies and emerging issue. Agro Forest. Syst., 59(3): 317-326.

Amudavi, M.A., 1993. Influence of socio-economic factors on adoption of maize related technologies: The case of smallholder farmers in Hamisi Division of Vihiga District, Kenya. M.Sc. Thesis, Egerton University, Njoro, Kenya.

Ani, A.O., 1998. Assessment of farmers' extension education needs in Yobe State, Nigeria. Niger J. Agric. Educ., 1: 152-8.

Ani, A.O., 2002. Factors inhibiting agricultural production among rural women in Southern Ebony State, Nigeria. Ph.D. Thesis, University of Maiduguri, Nigeria.

Ary, D., L.C. Jacobs and A. Ravavier, 1979. Introduction to Research in Education. Rinehart and Winston Publishers, Holt, New York.

Ascroft, J., 1973. The Overall Evaluation of the Special Rural Development Plan. Institute for Social Development, Geneva.

Barret, C.B., F. Place and A.A. Aboud, 2002. Natural Resource Management in African Agriculture: Understanding and Improving Current Practices. CABI Publishers, Oxford.

Blackburn, D.J., G.L. Brinkman and H.C. Driver, 1982. Understanding Behaviour and Economic Characteristics in Working with Operations of Small Farms: A Case Study in Ontario Canada. John Wiley, New York.

Chilot, Y., 1994. Factors influencing adoption of new wheat technologies in the Wolemera and Addis Alem Areas of Ethiopia. M.Sc. Thesis, Alemaya University, Alemaya, Ethiopia.

Chitere, P.A. and J.H. Van Doorne, 1985. Extension education and farmers performance in improved crop farming in Kakamega District. Agric. Admin., 18(2): 39-55.

Food and Agriculture Organization, 1987. Consultation on Irrigation in Africa: Proceedings of the Consultation of Irrigation in Africa. FAO, Rome.

Food and Agriculture Organization, 2004. Scaling Soil Nutrient Balances: Enabling Mesolevel Applications for African Realities. FAO, Rome.

Franzel, S., R. Coe, P. Cooper, F. Place and S.J. Sherr, 2001. Assessing the adoption potential of agro forestry practices in sub-Saharan Africa. Agric. Syst., 69: 37-62.

Government of Kenya, 2001a. National Agricultural and Livestock Extension Programme. Implementation Framework, MOARD, Nairobi.

Iheanacho, A.C., 2000. Economics of millet production under different cropping systems in Borno State of Nigeria. Ph.D. Thesis, University of Maiduguri, Nigeria.

International Federation of Agricultural Producers, 1996. Negotiating linkages: Farmers' Organizations, Agricultural Research and extension. IFAD: Nairobi, Kenya, pp: 40.

Jaetzold, R. and H. Schmidt, 1982. Farm Management Handbook of Kenya: Natural Conditions and Farm Management Information. Volume II/A: West Kenya. Ministry of Agriculture, Nairobi, pp: 397.

Legesse, D., 1992. Analysis of factors influencing adoption and the impact of wheat and maize technologies in Aris Nagele, Ethiopia. M.Sc. Thesis, Alemaya University, Alemaya, Ethiopia.

Marenya, P.P., C.B. Barret, W.A. Oluoch-Kosura and F. Place, 2003. Education, non-farm income and farm investment in land scarce western Kenya. A Basis CRSP Policy Brief No. 14, University of Wisconsin, Madison, WI.

Mwale, S.M., 1998. Integrating food and environmental security in the greater horn of Africa: A preliminary institutional stakeholder analysis. A Report Submitted to IUCN and WRI, pp: 67-79.

Nassiuma, D.K., 2000. Survey Sampling: Theory and Methods. Nairobi University Press, Nairobi.

Norman, D., D. Baker, H.G. Joha, C. Maskiara and F. Worman, 1989. Farmers Groups for Technology Development, Experiences in Botswana, in Chambers: Farmers Innovation and Agricultural Research. Intermediate Technology Publication, London.

Nye, P.H. and D.J. Greenland, 1960. The Soil under Shifting Cultivation. Technical Communication No. 51, Commonwealth Agricultural Bureaux, England.

Odera, M.M., S.K. Kimani and F. Musembi, 2000. Factors influencing adoption of integrated use of manure and inorganic fertilizer in central highlands of Kenya. Collaboration and Participatory Research for Sustainably Improved Livelihoods. Proceedings of the 7th Biennial Scientific Conference. Kenya Agricultural Research Institute (KARI) Nairobi, Kenya, pp: 58-64.

Okuro, J.O., F.M. Muriithi, W. Mwangi, H. Verjuikl, M. Gethi and H. Groote, 2002. Adoption of Maize Seed and Fertilizer Technologies in Embu District, Kenya. CIMMYT and Kenya Agricultural Research Institute (KARI), Mexico.

Oywaya, M.A., 1995. Socio-economic factors influencing innovation and participation of women in agricultural extension programmes in Malala Division of Makueni District, Kenya. M.Sc. Thesis, Egerton University, Njoro, Kenya.

Pfister, F., H.P. Bader, R. Scheider and P. Buccini, 2005. Dynamic modeling of resource management for farming systems. Agric. Syst., 86: 1-28.

Phiri, D., S. Franzel, P. Mafongoya, I. Jere, R. Katanga and S. Phiri, 2003. Who is using new technology? The association of wealth status and gender with the planting of improved tree fallows in Eastern Province Zambia. Agric. Syst., 79: 131-144.

Pieri, C.J., 1989. Fertility of Soils. A Future for Farming in West African Savannah. Springer-Verlag, Berlin.

Place, F., Franzel, C.B. Barret, H.A. Freeman, J.J. Ramisch and B. Vanlauwe, 2003. Prospects for integrated soil fertility management using organic and inorganic inputs: Evidence from smallholder African agricultural systems. Food Policy, 28(4SU): 365-378.

Quisumbing, A.R., L. Brown, R. Hillary, S. Feldsten, L. Haddad and C. Pena, 1995. Women: The Key to Food Security. Food Policy Statement No. 21. International Food Policy Research Institute, Washington, DC.

Rahmeto, N., 2007. Determinants of improved haricot bean production package in Alaba special wored, Southern Ethiopia. M.Sc. Thesis, Hamaraya University, Hamaraya, Ethiopia.

Reardon, T., C.B. Barret, V. Kelly and K. Savadogo, 2001. Sustainable versus Unsustainable Agricultural Intensification in Africa: Focus on Policy Reforms and Market Conditions. In: Lee, D.R. and C.B. Barret (Eds.), Tradeoffs or Synergies? Agricultural Intensification, Economic Development and the Environment. CABI Publishing, Oxford.

Rogers, E.M., 2003. Diffusion of Innovations. 4th Edn., The Free Press, New York.

Saito, K.A., H. Mekonnen and D. Spurling, 1994. Raising productivity of women farmers in Sub-Sahara Africa. The World Bank, Washington, DC.

Sanchez, P.A., B. Jama, A.I. Niang and C.A. Palm, 2001. Soil Fertility, Small Farm Intensification and the Environment in Africa. Trade Offs or Synergies? Agricultural Intensification, Economic Development and the Environment. CABI Publishing, Wallingford.

Sheikh, A.D., T. Rehman and C.M. Yates, 2003. Logit models for identifying the factors that influence the uptake of new "no tillage" technologies by farmers in the rice-wheat and cotton-wheat farming. Agric. Syst., 75: 79-95.

Smaling, E.M.A., J.J. Stoorvogel and P.N. Windmeijer, 1993. Calculating soil nutrient balance in Africa at different scales. II: District scale. Fert. Res., 35: 237-250.

Teressa, A., 1997. Factors influencing adoption and intensity of use of fertilizer: The case of Lume district, Central Ethiopia. Quart. J. Int. Agric., 36: 173-187.

Tittonell, P., 2003. Plant production system group. M.Sc. Thesis, Department of Plant Sciences, Wagenigen University and Research Centre/Tropical Soil Biology and Fertility Program (TSBF-CIAT), Nairobi, Kenya.

Van der Bosch, H., A. De Jager and J. Vlaming, 1998. Monitoring nutrient flow and economic performance in African farming systems (NUTMON). III. Monitoring nutrient flows and balancing in three districts in Kenya. Agric. Ecosys. Environ., 71: 65-82.

Vanlauwe, B., 2004. Integrated Soil Fertility Management Research at TSBF: The Framestudy, the Principles and their Application. Managing Nutrient Cycles to sustain Soil Fertility in Sub-Sahara Africa. Academy Science Publishers, Nairobi.

Vanleuw, B. and K.E. Giller, 2006. Popular myths around soil fertility management in sub-Saharah Africa. Agric. Ecosyst. Environ., 116: 34-46.

Wasula, S.L., 2000. Influence of socio-economic factors on adoption of agroforestry related technology. The case of Njoro and Rongai Districts, Kenya. M.Sc. Thesis, Egerton University, Njoro, Kenya.

World Bank, 2003. Reaching the Rural Poor: A Renewed Strategy for Rural Development. The World Bank, Washington, DC.

Yates, R.A. and A. Kiss, 1992. Using and Sustaining Africa's Soils. Agriculture and Rural Development Series No. 6. Technical Department, Africa Region, World Bank, Washington, D.C.

Young, A., 1997. Agro Forestry for Soil Conservation. CAB International, Oxford.