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Benefits, constraints and adoption of technologies introduced through the eco-farm project in Ethiopia

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IV. ACRONYMS

AJTK	Tach Armacho Judo Kombolcha
ATA	Ethiopian Agricultural Transformation Agency
AREI	Agricultural Resources and Environmental Indicators
FOA	Food and Agricultural Organization of the United Nations
GDP	Gross Domostic Product
GMHT	Genetically Modified Herbicide Tolerant
RCTs	Conservation Technologies
SPSS	Statical Package for the Social Sciences
RCT	Resource conservation technologies
UNDP	United Nations Development Programme
WFS	World Food Summit

V. ABSTRACT

In Ethiopia, uptake of new technology is low despite the fact that technology adoption has a direct impact on crop yield and household's income generation as well as increased nutrition level. The purpose of this study was to investigate the extent of adoption of introduced technologies. Improved crop varieties, fruit and fodder trees and soil management technologies were among the introduced technologies. The study was carried out in three districts namely: Adami Tulu Judo Kombolcha (ATJK), Mekhone and Tach- Armacheho respectively. Empirical data were collected from 102 farmers via questionnaires and focus group discussion. Among the respondent farmers, 83.8, 30.3, and 10 percent of the farmers in ATJK, Mekhone and Tach-Armacheho districts respectively were adopters of more than four introduced technologies. The majority of the farmers (84.4%) in Adami Tulu Judo Kombolcha (ATJK) district adopted maize varieties. Yield increases were more pronounced in maize than in sorghum. The new maize varieties were resistant to pests and diseases which partly explain why they were well received. In Tach-Armacho district the most technology was upland rice which was adopted by 67% of the households. Rice proved to be very economical and highly beneficial for farmers with extended family members. This was a new crop in this area. The most adopted technologies in in Mekhone district were dairy goat production which was adopted by 27.3% of the sampled families. Characteristics of a technology such as: simplicity, visibility of results, usefulness towards meeting an existing need and low capital investment promoted their adoption. Their choice to adopt is affected by profitability and an- inter related series of personal, cultural, social and institutional factors. Factors that limited the uptake of new technologies included lack of persistent rainfall, lack of education and risk aversion behaviour. As a result, to encourage the expansion of adoption in Ethiopia, it is essential to take into account the factors that influence farmers' adoption decision.

Keywords: Adoption, adoption decision, introduced technologies, Ethiopia

1. INTRODUCTION

Ethiopia's fundamental component of economic growth is agriculture and animal husbandry. Agriculture constitutes 46 percent of national GDP and an estimated 85 percent of the population is engaged in agricultural production. The lives of the majority of Ethiopian population depend directly on natural resources. Agriculture and especially farming are the two main areas in which most of the population depend on. Hence, 90 percent of the poor depends on this sector for their subsistence. So far, the traditional way of farming has not been able to guarantee food security. Ethiopia will thus remain vulnerable to famine and other consequences of climatic change until it adopts new farming technologies that the developing world is using to improve food security and the livelihood of its people. Farmers are the victims of the climate change and Ethiopia confronts several environmental issues that are particularly problematic for the agricultural sector of the economy. Such issues include deforestation (depletion of forests), over-grazing (depletion of pastures), soil erosion (depletion of quality soil), and desertification. Hence, it is essential for Ethiopia to address these environmental problems in order to maintain the land for agricultural activities.

It is known that currently the whole world is worried about climate change and the expected harm it may cause. The Ethiopian government is aware of the consequences of climate change. Based on this awareness, the government has embarked on an agricultural led growth strategy and has already made substantial investments toward improving the productivity of the rural people. Some of these measures include the establishment of agricultural oriented technological and vocational education and training colleges to train development agents who would be deployed to farmer training centers in different parts of the country. The government has contributed directly to poverty reduction strategies by improving the profitability of small farm holders and related agri-business firms. Thus Ethiopian Agricultural Transformation Agency (ATA) is trying to provide information on a technology platform to the small farm holders. Such as: pre-planting, planting, crop protection, post-harvest, fertilizer application, processing, irrigation, improving and marketing techniques. The strategy also emphasizes on employing modern agricultural inputs and promotes efficient resource utilization to help farmers move beyond subsistent farming to small-scale market- oriented agriculture (United Nations Development Program, 2013).

Consequently, efficient agricultural machinery, agricultural chemicals and fertilizers, genetic improvements in crops, and changes in farm management techniques have been seen to change and transform the sector. The introduction of those modern agricultural technologies to poor farmers has changed the amount of production and increased food security. At the same time the demand for employing modern agricultural technologies and production inputs is growing considerably. Although, both governmental and non-governmental bodies have been making every effort to meet the ever growing demand for modern agricultural inputs, there is still an unmet demand. Particularly, there is a growing demand for improved seeds. Most certified seeds are supplied by the subsidized public seed enterprises. Therefore, development-oriented local projects funded and supported by the donor countries are undertaken to help alleviate the improved seed supply shortage.

Ethiopia, whose economy is heavily based on agriculture, is one of the developing countries that Norway has prioritized to provide improved agricultural technologies and implement the transfer of new technologies to the needy. Eco-farm project is a project intended to increase farmers' knowledge on employing modern agricultural technologies. It is also aimed at enhancing farmers' participation in research that helps increase their outputs. As a result, encouraging out-comes have been registered, especially in transferring and adopting new technologies in the agriculture sector through the involvement of farmers in the research activities. The eco-farm project, a project of the Dry land Co-ordination Group, introduced and implemented improved technologies of farming in three different areas in Ethiopia. The total number of farmers were 238. The introduced technologies were crop varieties (rice, finger millet, maize and sorghum etc...), fruits and fodder trees such as Moringa (locally called Aleko or Shiferaw), Avocado, Papaya, and Mango etc. Besides these, soil management activities like conservation tillage, seed priming, micro fertilization, intercropping, sowing date and harvesting of maize at physiological maturity are considered and included in the project implementation. Simultaneously, to raise the income of poor female headed households, activities like silk worm rearing, dairy production, and honey bee were introduced. Thus, the point of emphasis in this research is to find out the level of adoption of the technologies and the effect of adopting these technologies on living standard.

Therefore, the common measurement method, a two variable dichotomy, which is YES or NO was used to measure the level of adoption (Ovwigho and Ifie 2007; Imbur et al.2008; Sezginet al.2011). To obtain the level of adoption, percentile value was used to calculate the ratio of adopters. It was done by asking farmers to respond a yes or no answer to the technologies they

have adopted. As a result, the numbers of adopted technologies were used to evaluate the adoption level.

In this paper, the researcher examines the level and determinants of adoption of the promoted technologies. Specifically, the objectives of this study are to assess the extent of adoption of the introduced technology package by eco-farm project and to determine the main economic factors affecting utilization of the adoption process.

Based on the data collected, this paper assesses the adoption of the introduced agricultural technologies and its effectiveness in increasing the farmers' income, reducing their vulnerability to climate change, improving their nutrition, and preserving the environment in one of the Sub-Saharan African countries, Ethiopia.

Accordingly, this paper has eight chapters: chapter one contains the introduction, chapter two deals with the literature review; chapter three presents materials and methods. Chapter four covers the results and discussion, chapter five presents adoption rate, chapter six deals with why are some technologies adopted and others not, chapter seven encompasses spontaneous uptake of technologies, chapter eight deals with how the adoption relates to adoption theory and the final chapter, which is chapter nine closes with the conclusion.

1.1 PROBLEM STATEMENT

The study investigated the sustainability of the introduced technologies after the project phased out.

1.2 STUDY OBJECTIVES AND RESEARCH QUESTIONS OF THE STUDY

The objectives of the study is to assess the adoption of new agricultural technologies in rural areas and study how the famers are dealing with the effects of climate change.

Research questions:

- How easy is it to adopt the new technologies?
- Do the farmers still continue to use the introduced new technologies after the phase-out stage of the eco-farm project?
- How much of the land is covered by the new technologies?
- Which factors were important in their adoption decision?
- To what extent is there a spontaneous uptake of the technologies?

2 LITERATURE REVIEW

2.1 THE IMPORTANCE OF ADOPTION NEW TECHNOLOGIES

The increasing complexities of environmental problems are likely to increase the necessities of new agricultural technologies that can be used to minimize the potential contribution of negative environmental consequences of agricultural production. Climate change poses threats, but the effect is still difficult to predict. Climate change will affect crop and livestock yields worldwide, which will lead to change in food and fiber consumption, prices of agricultural commodities, and farm income (USDA, 2014). However, agriculture is a source of methane and nitrous oxide emissions which are the two prominent greenhouse gases. So changes in agricultural practices could potentially reduce or increase emission of these gases. Adaption to climate change has been suggested as a means to reduce the impact of climate change on individuals and societies.

According to the Agricultural Resources and Environmental Indicators (AREI) many technologies that have been developed have the potential not only to increase farm productivity, but also to reduce the environmental and resource costs associated with agricultural production such as land and water by increasing yields with the same or fewer inputs and technologies. Besides, agriculture can provide many public goods and services or externalities like land conservation, maintenance of landscape structure, biodiversity preservation , nutrient recycling and loss reduction and so on (Boody et al. 2005).

Different studies have shown that different technologies can positively affect soil properties and yields. Furrow diking contribute to economic stability through reduced water consumption and yield and net returns. (Nuti et al. 2009). Technology adoption practices can include good agrarian practices, irrigation scheduling, water saving, conservation tillage, organic farming, erosion reduction, nitrogen fertilization and plastic covered horticulture (Bertuglia et al. 2006).

A study conducted on agricultural productivity and policy change in nine sub- Saharan African countries namely: Angola, Nigeria, Ghana, Mozambique, Guinea, Cameroon, Mali, Zambia, and Ethiopia shows that structural adjustment policies that led to implementation of more favorable new agricultural technologies. More efficient use of inputs, improved performance of output growth and changes in the relative use of inputs brought about a significant increase in output per hectare (Yu and Nin Pratt*, 2011*).

A study conducted in West Africa (Niger) which evaluates the adoption of cereal technologies of peasants and how the decision making under weather/rainfall uncertainty affects the adoption process. Concluded that in Sub- Saharan African countries often times family labor which is lower opportunity cost used to adopt labor intensive technologies (Adesina and Sanders, 1991).

A study by (Maredia and Minde, 2002*)* explored the relationship between profitability of agricultural technologies and its adoption by farmers in Eastern Africa. The study showed that some profitable technologies such as improved cassava varieties in Uganda and improved coffee varieties in Kenya were adopted. Some other technologies that were not fully adopted or had been restricted to on-farm demonstration plots such as wheat variety and hybrid maize in Ethiopia and the application of inorganic fertilizer on maize in Kenya. The lower adoption level was related to non-technological constraints (e.g. infrastructure, policies, input/output markets, and adverse climatic conditions) which reduced profitability and adoption of new technologies. For this reason there is a need for continuous efforts to supply technologies that are adapted to the prevailing environmental conditions.

Research conducted in Bangladesh (Yan Liang, 2006) found that income increase by the adoption of transgenic rice will reduce each individual household's probability of suffering future consumption shortfall. It states that the private sector, however, in its pursuit of profit, often either choose to invest in crops (cotton, maize) or traits (herbicide tolerant) that are less relevant to poor farmers in developing countries, or charging a premium for new biotech-products. The research concluded that the likelihood of the transgenic rice would follow the same pattern if it were developed by the private sector. Research by the public sector such as: the international research centers and national research institutes will more likely benefit marginalized farmers.

A study in India (Nick.M, et al, 2011) shows that introducing 'Happy Seeder': a tractor-powered machine that cuts and lifts the rice straw sows into the bare soil and deposits the straw over the sown area. It offers on-farm benefits through higher crop yields, increased cropping opportunities, less weed growth, improved soil quality and structure and lower water consumption. The introduction of this new technology 'Happy Seeder' therefore appears to have considerable promise to provide environmental and community benefits. It is an alternative to burning as a means of managing rice residues. Besides to this, an introduction of conservation technologies (RCTs) in India with the primarily focus on resource savings through minimal tillage, ensuring soil nutrients and moisture conservation through crop residues and growth of cover crops, and adoption of spatial and temporal crop sequencing. In this study rice-wheat

cropping system has clearly indicated the superiority of resource conservation technologies over conventional practices in terms of cost saving and more efficient use of inputs. The adoption of RCTs provides a considerable saving in the use of human and mechanical labor. (N.P. Singh, 2011)

2.2 FACTORS AFFECTING ADOPTION

Farming is an undertaking which occupies the daily routine of most agricultural producers and involves numerous important decisions such as: what crops to plant, what inputs to use, when to plow, when to seed, how to irrigate, how and when to harvest, how much to keep for home consumption, how much to sell and how much to store for later sell. What is unique about agriculture is that literally millions of individuals and households are making these decisions themselves. Technology adoption is important because it is a means that allows people to participate in a rapidly changing world where technology has become crucial to their lives. The word "adoption" refers to the stage in which a technology is selected for use by an individual or an organization. Besides, technology users differ widely in their attitudes towards technology.

The Bridge to Technology.com define technology adoption as a process that begins with awareness of the technology and progresses through a series of steps that end in appropriate and effective usage. According to this source, technology adoption consists of five steps:

First, technology adoption requires awareness. At this step the potential users get adequate information about the benefits of the technology. The second step is assessment. At this level, the expected users evaluate the usefulness and usability of the technology, and the ease or difficulty of adopting. This is followed by acceptance or refusal of the users. At this stage, they decide to acquire and use the technology, or not. The fourth stage is learning. If they decide to use the technology, the users need to develop the skills and knowledge required to use the technology effectively. Finally, application or usage comes. Here the users show appropriate and effective use of the technology. When we boil down this to the context of farmers, adoption essentially consists of a personal decision about what to do. Different factors determine the adoption of different agricultural innovations and technologies. Much empirical adoption literature focuses on farm size as the first and probably the most important determinant (*Harper et al, 1990; Daku, 2002;* Nkonya *et al,* 1997; and Doss and Morris, 2001). A study by (Gabre-Madhin and Haggblade*,* 2001) found that large commercial farmers adopted new high-yielding maize varieties more rapidly than small farm holders. Koundouri *et al,* 2002 argue that farmers'

decision to adopt a new technology is affected by risk factors which is related to production risk and how the new technology can change the amount of production and profitability of the farmers. Particularly, farmers with poor farming practices and use of traditional agricultural appliances are afraid of taking risks to adopt new ways of farming practices. Kosarek et al., 2001 also found that farmers' decision to adopt hybrid maize was determined by the expected returns (i.e. profitability) of the technology, the availability of hybrid seed, and risks associated with the expected outcomes of the new technology. An empirical study on technology adoption in Sub-Saharan Africa found out that risk is extremely important. Besides education of the farmers, credit availability, extension services were all important in determining hybrid maize verities use. (Gerhart, 1985)

Adoption and expansion of any agricultural activity mostly depend upon the profitability and cost of the technology. With small farms, it has been argued that large fixed costs become a constraint to technology adoption (Abara and Singh, 1993) especially if the technology requires a substantial amount of initial set-up cost. Hence the adoption decisions of farmers can be influenced by the cost and benefit of the technology. Proper investigations that take into account the costs and benefits resulting from the technology are needed, which may help in reducing economic risks and influence in adoption and expansion of such technologies. The possibility of over-estimation of yield and profitability are the issues of concern of farmers (Singh *et al.,* 2006). Besides the benefit received and the payback period of the technology also has its effect on the adoption decision of the farmers. According to the study conducted in India (Goswami, Kishor*; et al* 2011*)* the introduction of jatropha seed: a good feedstock for the bio-diesel industry in India was introduced and the study has shown positive returns from the plantation. The adoption and expansion of jatropha plantation in the rural areas largely depends on profitability from such plantations at farmer's level. This is because the payback period of plantation and the high seed yield will be achieved after five years and accordingly funding support for operation and maintenance of such plantations at least during the initial years is required.

Strauss *et al.,* 1991 found the farmer's education level contributed positively to the probability of soybean farmers performing soil sample analysis to determine the quantity of fertilizer that they should apply on their rice fields. Similarly, a study by (Rahm and Huffman 1984) designed to evaluate the role of human capital and factors that affected the adoption of reduced tillage in corn production found that farmers' education and experience play a crucial role in enhancing the efficiency of the adoption. According to (Rogers, 1983) technology complexity has a negative effect on adoption and could be dealt with only through education.

A study by N.P. Singh, 2011 found that the probability of a farmer adopting a resource conserving technology depends upon ‘‘increase in net income due to adoption of technology, education level of household- head, total irrigated cropped area, source of information, and possession of tractor by farm household and ability of the technology to save resources like labor’’. Age is an important factor which influences the probability of adoption of new technologies because it is said to be a primary latent characteristic in adoption decisions.

Factors like the total land area and the total number of animals will affect farm household’s production decisions of rice. The study showed that the animal asset and the percentage of rice areas have the largest impact on a household’s profit (Yan Liang, 2006).

According to *Kassie et al, 2009* adoption decisions can also be significantly influenced by land rights and the future security of tenure among farmers. The rapid adoption of GMHT crops were explained by the economic benefits results from higher yields or reduced costs, production efficiency and flexibility and simplification of conservation tillage (Dill *et al.,* 2008).

More importantly a farmer might reject the use of technology at any time during or after the adoption process when he/she questions the right of land ownership. Moreover, if a new technology fails in its early stage, the subsequent rate of improvement is an important determinant of adoption of the technology (Khan and Hall, 2003). This is because the failure of the new technology at its first stage may create doubt and even total rejection by the farmers. They may question the reliability of the new technology and may decide not to continue using it.

Furthermore, there may be gender differences in the adoption of different technologies. For most of the Ethiopian farmer households, the man is the head of the house and the possibility of female participation in the technology uptake decision is not as such significant. As primarily a patrilineal community, the man is often the decision maker when it comes to agricultural managements. In addition to that, access to resources is also one factor that influences adoption. Accordingly, men have better access to resources than women do. Morris, 1999 found out that women’s adoption of technology depends on access to land, labor, or other resources. For this reason, technologies will not benefit men and women farmers evenly.

Doss, 2007 also stated that; it is useful to collect information whether or not farmers have ever used improved technologies before in order to understand and introduce new technologies. In addition, Koundouri *et al,* 2006 also wrote that farmer’s information about the new technology

plays a significant role in deciding to adopt the improved agricultural technology. The extent to which farmers learn from each other and the influence of social network can also play a vital role in accepting and disseminating new technologies to a large population. The main source of information for farmers is other farmers because information is easily available and it is not too costly to utilize it (Gershon *et al, 2004*). This is confirmed by a survey data which showed that farmers cite other farmers as their main source of information regarding agricultural practices (Feder and Slade, 1985 and Rees *et al, 2000*).

Furthermore, innovation systems offer an understanding of how small farm holders experiment and further develop new knowledge and technologies in processes of learning by doing and learning from others in the context of complex social relationships (Leeuwis, 2004). In addition to this (Fromm *et al,* 2010*)* also note that, the dynamics of social networks of exchange of information, knowledge, learning, and discussion experiences and building of confidence for adopting innovations among small scale farmers in developing countries is still lucks awareness. Farmers operate under a situation of acute risk, low and highly erratic rainfall (Sivakumar, 1988). Rainfall and poor soils have been shown to differentially affect the yield potentials of the various crops (Kassam and Kowal, 1973). It is therefore necessary to know that the reasons for low rates of adoption can include social, cultural, economic, technical and environmental factors (Jamison and Lau*,* 1982).

In general, understanding the role of factors that influences adoption decisions is critical to successful agricultural development. Different factors determine the adoption of different agricultural innovations and technologies. Beliefs and perceptions of farmers, communities and absence of institutional innovations have impact on adoption decision. There is a risk and uncertainty factors for small scale farmers in adopting new technologies. The technologies may seem attractive but they may not be willing to accept the financial risk involved largely because of the acute risk. In general, in order for the technology contribute to the realization of the goals of the farmers and to be adopted, the need to understand the role of factors that influences adoption decisions is crucial. Thus to a successful agricultural development it is therefore necessary to known that the reasons for low rates of adoption can include social, cultural, economic, technical and environmental factors.

3 MATERIALS AND METHODS

Multiple methods of data collection were employed such as: structured interview, focused group discussion and observation.

3.1 THE SURVEY

The structured questionnaire was designed in order to collect information about the farmers' adoption of the new technologies. The questionnaires were administered face-to-face as it provided the opportunity for further probing. The first section aimed to collect basic information such as age, sex, level of education and family size. The second section included research related questions such as the extent of technologies adopted, level of constraints and benefits of eco-farm project technologies introduced to the farmers as well as the advantages and problems of adopting the technology and the willingness of farmers to seek information about new technologies and etc....

The objective of this study was to investigate the ways farmers acquire and adapt the technology. Thus, a total of 102 farmers were interviewed face-to-face in the three selected areas: ATJK wereda of Oromia region, Tach-ArmachihoWereda of Amhara region and Raya Azebo and Hintallo Wejerat Weredas of Tigray. In each area 32, 37 and 33 farmers were interviewed respectively. The farmers were selected through the help of a local agricultural assistance. The interviews were conducted by meeting the respondents at their respective homes, market places and social events or gatherings. The interviewees were mostly close-ended questions that are very specific and offered them a fixed range of answers. In addition to close-ended questions, a few open-ended questions were asked concerning the socio-economic situation of the respondents.

3.2 THE FOCUS GROUP DISCUSSION

The focus group discussions were used as an exploratory tool to discover peoples' thoughts and feelings and to obtain detailed information about various subjects. The group setting was organized by grouping farmers from the three categories: younger boys, older men, and female farmers. With the assistance of the key informants, three focus groups each consisting of six to nine people were formed. Participants are chosen on the basis of their experience. Likewise, most of them who participated in the group discussions were farmer leaders. Data were

generated from the interaction between members of the group. Discussions were held with farmers known to have better than average knowledge of technology practices. The group setting was generally characterized by a synergistic effect whereby participants explored different points of view and formulated their own ideas and understandings. The data were collected on weekends where farmers are relieved from their farming activities. This ensures that the discussions and the time for participants to contribute are not too limited (Russell, 2002 and Ritchie, 2003). This method allows identifying key issues and helping to understand the perceptions, insights into needs, expectation, attitudes, and feelings of the farmers in relation to the adoption process. It also helps to develop interview schedules for the household survey questionnaire. This kind of exchange resulted in lots of information such as: economical, technical, environmental aspects and socio-cultural characteristics being generated and discussed.

3.3 OBSERATION

The third method I used was observation. Observation method was quite practical for me, because the time of my data collection coincide with the rainy season when farmers are carrying out field activities. I observed how farmers made use of the technologies and experimented how the new technologies actually work.

3.4 PROBLEM ENCOUNTERED IN DATA COLLECTION

I had to face problems with questions that required respondents to recall events in the past. These included questions such as: the amount of production harvested, quantity sold or consumed and amount of money spent on expenditure.

3.5 DATA PROCESSING AND ANALYSIS

The data is analyzed in both qualitative and simple quantitative methods such as percentage and other statistical comparisons. Quantitative data analysis is used for the data collected through structured interview and qualitative data analysis is used for data collected through focused group discussion and observation. Analysis of survey data was processed through manual editing and coding which was eventually analyzed using SPSS. The focus group discussions, in-depth interviews and audio records were further manually analyzed and interpreted through the production of descriptive and explanatory accounts.

4 RESULT AND DISCUSSION

4.1 DESCRIPTION OF THE STUDY AREA

The eco-farm project in Ethiopia was introduced in three different regions (following a study conducted by Dry land Coordination Group, 2008): 'Oromiya Regional State, Tigray Regional State and Amhara Regional State. The study areas in Oromiya region include Ellelan Ababo, Leliso Dambe and Ciitu Getto in Adami Tulu Jiddo Kombolcha (ATJK) Wereda. In Tigray region, the specific areas include four villages namely: Genete, Tsegea, Tsehafti and Tulebo in Raya Azebo and HintaloWejeratWeredas. In Amhara region, the study areas are two villages, Sanja and Filwuha, in Tach Armachiho Wereda.

In Oromiya region, the project sites are located at an altitude ranging from 1700 to 1800 m.a.s.l. This sample wereda receives an average rainfall of 400-600 mm per annum. The rainfall distribution is erratic with high evapo-transpiration rates for most of the year. The soils of ATJK Wereda are mainly sandy loam with degraded vegetation cover.

The two project weredas in Tigray region, Raya Azebo and HintaloWajerat are located at an altitude ranging from 930 to 1800 and 450 to 2400 m.a.s.l., respectively. The weredas receive an average rainfall of 400-700 mm. The rainfall in Tigray region has an erratic distribution with high evapo-transpiration rates, which often exceeds rainfall in most of the year. The soils of Raya AzeboWereda in particular are mainly sandy loam.

In Amhara region, the project wereda, TachArmachiho, is situated at an altitude ranging between 950 and 1050 m.a.s.l. This area receives an annual rainfall ranging between 800 and 1800 mm. The average temperature is 25-42^{O}C. Vertisols are the dominant soil type.

4.2 FARMING SYSTEM

Dryland areas' farming system is a rain fed, mixed cropping system. The rains tend to be intense and erratic; droughts are frequent and may persist for several consecutive years. The erratic character of the rains makes dryland cropping very unreliable despite relatively high rainfall during parts of the year. Sorghum, millets and maize are the principal crops mainly grown for local consumption. Farmers in these areas generally use local varieties which have been grown for generations and are adapted to local conditions such as climate, soil, pests and diseases, yet they have limited yield potential. Crop yields ultimately depend on the weather during the

growing season and especially on the distribution of the rainfall. With good rainfall, farmers produce more grain than they need for their own consumption. Sales enable them to buy and pay for essentials. However, during a poor rainy season production may be too low to cover food demand until the next harvest. In order to ensure food security and sufficient production to generate an income, better use of rainwater is vital. So having this in mind some rainwater harvesting is undertaken.

4.3 HOUSHOLD CHARACTERSTICS

This section deals with the general characteristics of the sample population, including composition by age and sex, household size, education, length of time as a farmer, land size, cultural beliefs against any technology and previous use of technologies.

Each individual farm has its own specific characteristics, which arise from variations in resource endowments, family circumstances and the use of farming equipment. The household, its resources, and the resource flows and interactions at this individual farm level are together referred to as a farm system. According to Food and Agricultural Organization of the United Nations (FOA) a farming system is defined as a population of individual farm systems that have broadly similar resource bases, household livelihoods and constraints, and for which similar farming technologies and development strategies and interventions can be determined.

4.4 HOUSEHOLD POPULATION BY AGE AND SEX

The head of a household is defined as: “the one who manages the income earned and expenses incurred by the household and manages the farming system all in all. It is considered by other members of the household as the head of the household.” The household head could either be male or female. However, in the rural areas the female is allowed to be the head in circumstances where the man is not present in the house.

Table 1 shows percent distribution of sample households by sex of head of household in three districts. The sex composition of the population shows significant variation by the proportion where men constituting 100, 89 and 72 percent in ATJK, TachArmacho and Mekone respectively. Women constituted 0, 10 and 27 percent of the household head population in ATJK, Tach-Armacheho and Mekohone respectively. The data revealed that the proportion of female- headed households is still low.

TABLE 1 PROPORTION OF SEX OF HOUSEHOLD HEADS IN THREE DISTRICTS IN ETHIOPIA.

District	Sample	Sex of household heads (%)	
		Male	Female
ATJK	32	100	-
Tach-Armacheho	37	89.20	10.80
Mekhone	33	72.70	27.30

Table 2 shows the age distribution of the sample household population in three areas. The age composition of the sample population shows that the youngest farmer was 19 years old and the oldest 80 in Tach- Armacheho. The data shows the average age group.

TABLE 2 AGE OF HOUSEHOLD HEADS INCLUDED IN ECO-FARM PROJECT IN THREE DISTRICTS IN ETHIOPIA

District	Samples	Minimum	Maximum	Mean	Standard Error
ATJK	32	22	50	34	1.41
Tach-Armacheho	37	19	80	44.59	2.18
Mekhone	33	30	74	47.82	2.16

4.5 HOUSEHOLD FAMILY SIZE

Household family size includes the number of usual resident members in a household. Usual resident members are defined as those who have lived in the household for at least 6 months during the previous 12 months. It may include fostered children, grandparents and other relatives who have joined the household with the intention to live permanently or for an extended period of time.

TABLE 3 FAMILY SIZE OF INCLUDED HOUSEHOLDS IN THREE DISTRICTS IN ETHIOPIA

District	Samples	Minimum	Maximum	Mean	Standard Error
ATJK	32	3	18	8.56	0.61
Tach-Armacheho	37	2	10	5.59	0.30
Mekhone	33	2	11	5.94	0.34

Table 3 indicates that ATJK has the highest number of household members (18 persons), 10 in Tach-Armacheho and 11 persons in Mekhone. The table also shows that the mean household size is 5.59 persons in Tach- Armacheho which is slightly lower than Mekhone.

4.6 EDUCATIONAL LEVEL OF HOUSEHOLD POPULATION

Education is an important variable regarding adoption behavior. Higher education is usually associated with greater knowledge and greater adoption level. Many studies have shown that educational level is strongly associated with the diffusion of technologies. Research in Asia (Jamison and Lau, 1982 and Phillips, 1994) showed that education beyond a threshold of about four years speeds the adoption of improved plant varieties. The diffusion of new agricultural technology is expected to raise farmer's incomes and improve their nutrition. Therefore, highly educated farmers tend to adopt productive innovations earlier than those who are relatively less educated. Empirical evidence suggests a positive relation between education and the adoption of new technology (Asfaw and Admassie 2004 and Rahman, 2007). Besides, many economists have found that farmers' education increases the probability of adopting new agricultural technologies such as high yielding varieties.

TABLE 4 HOUSEHOLD EDUCATION IN THREE DISTRICTS IN ETHIOPIA

Level of education of household head	District		
	ATJK (n = 32)	Tach-Armacheho (n = 37)	Mekhone (n = 33)
Illiterate (%)	3.1	37.8	45.5
Read and write (%)	-	13.5	12.1
Grade 1 to 4 (%)	28.1	29.7	33.3
Grade 5 to 8 (%)	53.1	10.8	6.1
Grade 9 to 10 (%)	12.5	5.4	-
Above 12 (%)	3.1	2.7	3

Note: n = the number of sample house hold heads

Table 4 shows the level of education attained by household heads as formal education. As shown in the table, the vast majority 37.8 and 45.5 percent of farmers in Tach- Armacheho and Mekhone respectively have not attended formal education. Although many have not complete primary school, 53.1 percent of farmers in ATJK district have education level of grade 5 to 8. Illiteracy was another challenge to farmers. The adoption process requires understanding measurements. It is apparently a necessary condition for bee hive makers to be precise so that they can manage the movement of hives from compartment to compartment. Due to this fact, it is difficult for an uninformed farmer to do it without help. As a consequence they are forced to do it by trial and error and this requires more energy and time on simple arithmetic work.

4.7 HOUSEHOLD SIZE OF LAND

Farmers in the three areas share three common things: they live in a rural area, they rely on traditional farming system and they don't own the land they till or have small size of land. In those areas land is acquired through ancestry accession. Each family is obliged to share land to the younger generations. Therefore, the size of land decreases as the family size increases. For example farmers with large farm land could be used to adopt more technologies.

Table 5 shows the total size of land on which the new technologies are tested. The total size of land were used for different technologies at different times. The time span where the land size used was starting from the technology introduction until the data collection time period. Zero size of land implies that some of the participants in Mekhone were women involved only on dairy goat production with no farmland used for crop production. The results revealed that land size and ownership particularly have positive impact on the decision to adopt new technologies. While lack of alternative land for farming was significantly the greatest constraint to land allocation to the new technologies. Land access and control was significantly the highest constraint to allocation of land. ‘‘The bigger the land size I have the more I adopt new technologies’’ said a farmer in Tach-Armacheho.

TABLE 5 THE TOTAL SIZE OF LAND (IN HECTARE) ON WHICH NEW TECHNOLIGES WERE TESTED IN THREE DISTRICTS OF ETHIOPIA.

District	Samples	Minimum	Maximum	Mean	Standard Error
ATJK	32	1.00	5.00	2.72	0.19
Tach-Armacheho	37	0.25	15.00	4.74	0.57
Mekhone	33	0	1.5	0.14	0.05

Farm size is often one of the first factors measured when studying adoption processes. Empirical studies have consistently shown farm size (that is land area) to be significantly related to the adoption of new technology (Feder and Umali 1993 and Nkonya et al., 1997). Effects of farm size vary depending on the type of technology being introduced. However, it is known that when farmers have land of their own, they have opportunities and means to improve nutrition, income, and production. Hence, larger farm land implies higher adoption rates. The results are supported by similar studies on the effect of a farm size and technology adoption where (Shortle and Maranowski 1986) and (Lee and Stwart 1993) have all concluded that the bigger the plot size, the greater the chances of technology adoptions. Besides, farmers with larger farm were more likely to adopt new technology side by side with the traditional technology. Additionally, the sizes of lands are the most important determinants of farmers’ application of improved technologies.

4.8 HOUSEHOLD YEARS OF FARMING EXPERINCE

Farmers in the three districts are small holders who ensure food security by growing their own food. They practice rain- fed farming and use traditional farming system. Besides, farmers in the three districts have to do field work by hand or use horse (ox)-drawn equipment. This kind of manual farm work takes a long time to complete and is obviously exhausting. The table below shows the number of years spent in farming and years of experience on the field. Majority of 35, 65, and 52 percent of farmers in ATJK, Tach-Armacheho and Mekhone have been practicing traditional way of farming for decades.

TABLE 6 LENGTH OF TIME (YEARS) IN FARMING OF IN THREE DISTRICTS IN ETHIOPIA (MEMBERS OF ECOFARM PROJECT).

District	Samples	Minimum	Maximum	Mean	Standard Error
ATJK	32	6	35	18.25	1.30
Tach-Armacheho	37	1	65	21.03	2.19
Mekhone	33	10	52	28.18	1.78

4.9 HOUSHOLD CULTURAL BELIFS AGAINEST INTRODUCED TECHNOLOGIES

Farmers were asked to answer if there were any cultural believes against introduced technologies with the intention to provide information regarding cultural beliefs as a reason to resist the introduced technologies. As table 7 shows, 15.2 percent of male farmers in Mekhone who responded YES answered that the dairy goat production introduced to women was unnecessary and against the cultural believes. In addition, there were also are crops that were culturally considered to be bad for the health which led them not to be adopted by the farmers.

TABLE 7 CULTURAL BELIEFS OF FARMERS AGAINST ECO-FARM TECHNOLOGIES IN THREE DISTRICTS IN ETHIOPIA.

District	Samples	Cultural beliefs against the technology	
		Yes	No
ATJK	32	9.4	90.6
Tach-Armacheho	37	18.9	81.1
Mekhone	33	15.2	84.8

4.10 HOUSEHOLD PREVIOUSE USE OF AGRICULTURAL TECHNOLOGY

Table 8 shows the farmers' previous use of any kind of improved agricultural technologies before the arrival of eco-farm project. There were some new agricultural crops they already started using such as: improved maize crops distributed by the government agencies. Table 8 also presents that 62.5, 8.1 and 33.3 percent of farmers in the three districts of ATJK, Tach-Armacheho and Mekohone respectively respond positive to a previous use of agricultural technologies. However, as the result shown in the table below, most of the farmers responded negatively to previous use of any new agricultural technologies before the eco-farm project came.

TABLE 8 PREVIOUS USE OF NEW AGRICULTURAL TECHNOLOGY BY FARMERS IN THREE DISTRICTS IN ETHIOPIA.

District	Samples	Proportion in percent		
		Yes	No	I do not know
ATJK	32	62.5	37.5	-
Tach-Armacheho	37	8.1	86.5	5.4
Mekhone	33	33.3	66.7	-

5 ADOPTION RATE

The eco-farm project emphasize on improved yields has undeniably been successful. Nearly all of farmers involved in the project in ATJK and Tach-Armacheho districts benefited due to yield increases. Hence, increased yields have contributed to greater food security by farmers. Among the eco-farm project included households 93.8 % of the respondents in ATJK district and 89.2 % of the respondents in Tach-Armacheho district reported that adopting the introduced eco-farm technologies is easy. Moreover, other respondents: 6.2 %, 8.1 % and 100 % in ATJK, Tach-Armacheho and Mekhone districts, respectively, reported that adopting the introduced eco-farm technologies is very easy. On the other hand, only few respondents in Tach-Armacheho district (2.7 %) reported that adopting the introduced eco-farm technologies is difficult (Table 9). This clearly shows that there was little or no problem in adopting the introduced eco-farm technologies by farmers in the three districts.

TABLE 9 SIMPLICITY OF ADOPTING ECO-FARM TECHNOLOGIES BY FARMERS IN THREE DISTRICTS IN ETHIOPIA.

District	**Samples**	**Easiness of adoption of new eco-farm technology (in percent)**		
		Very easy	Easy	Difficult
ATJK	32	6.2	93.8	-
Tach-Armacheho	37	8.1	89.2	2.7
Mekhone	33	100	-	-

The fact that sufficient information about the technologies was provided to the farmers at the introduction stage helped simplify the technologies and the adoption process. Accordingly 84.4%, 75.7 % and 97 % of farmers in ATJK, Tach-Armacheho and Mekhone respectively (Table 10) confirmed the information given was adequate.

TABLE 10 PROPORTION OF FARMS AGREEING THAT SUFFICIENT INFORMATION WAS GIVEN ABOUT THE TECHNOLOGIES

District	Number of samples	Proportion in percent	
		Yes	No
ATJK	32	84.4	15.6
Tach-Armacheho	37	75.7	24.3
Mekhone	33	97	3

In addition, previous use of agricultural technology to some extent influenced the farmers' perceptions about the new technologies. Some of the technologies introduced were not new to the farmers, but came as improved once. The dairy goat production, bee-keeping, and most of the crops had been part of their agriculture activities. More importantly, 95% of them agreed that there were no cultural problems associated with trying to accept new ideas.

The survey also revealed that at the time of data collection four or more eco-farm technologies were adopted. Around 93.8, 30.3, and 10 percent of the farmers adopted more than four introduced technologies in ATJK, Mekhone and Tach-Armacheho respectively (table 11). The analyses showed that the number of adopted technologies refers to choice and subjective evaluation of farmer's decision to which technology to adopt. Farmer's performance was significant determinants of the adoption of new technologies. Characteristics of a technology such as: simplicity, visibility of results usefulness towards meeting an existing need and low capital investment promote their eventual adoption. Their choice to adopt considers profitability and an inter-related series of personal, cultural, social and institutional factors.

TABLE 11. EXTENT OF ADOPTING ECO-FARM TECHNOLOGIES BY FARMERS IN THREE DISTRICTS OF ETHIOPIA.

District	**Number of adopted eco-farm technologies (in percent)**			
	One	Two	Three	Four or above
ATJK	-	3.1	3.1	93.8
Tach-Armacheho	35.1	29.7	24.3	10.8
Mekhone	3	36.4	30.3	30.3

Only 35.1% of Tach-Armacheho farmers adopted one technology, while in Mekhone 36.4% adopted two technologies (Table 11). It can be said with fair amount of accuracy that crop production level leads farmers to decide on the number of technologies to adapt each year. The crop with more harvest or production has the highest probability of expansion in the coming year. Besides, the information exchange among farmers is also one way of informing each other about which crop had the highest level of production in the year. Therefore, the extent of the spontaneous uptake of the technologies mainly depended on the level of production.

5.1 INDIVIDUAL DISTRICTS ADOPTION LEVEL: ATJK, TACH-ARMACHEHO AND MEKHONE

5.1.1 ATJK DISTRICT ADOPTION LEVEL

Out of the many crops that were expected to influence farmers in ATJK, new varieties of maize were adopted and benefited many farmers. The adopters of maize increased their respective crop yield due to superior varieties introduced coupled with information on their management. Maize varieties were resistant to pests and diseases which partly explain good maize husbandry that is positively adapted. Yield increases were more pronounced in maize than sorghum indicating the significance of maize in the farming system of these areas not only as food but also as cash crop. Long- term yield trends do not show evidence of deteriorating growth.

The major maize insect pest in the area is stalk borer. Farmer's informed that these crop losses would be doubled if existing pesticide uses were abandoned. Application of insecticides such as permethrin dust is mandatory. Even after harvest, crops are subject to attack by pests or diseases. Maize is harvested once it reaches physiological maturity as signified by the formation of a black layer on maize grain. Harvested maize should be dried and stored in a cool dry place and treated against weevils with an insecticide such as Actellic 50 EC at recommended rates. However, lack of storage facility and shortage of insecticides was a challenge in the areas.

The practice of inter- cropping which is common in legume crops in many parts of ATJK was one of the most used farming management technologies which helped farmers to grow two crops side by side. The change in cropping patterns substantially increases gross margin and cash income. Legumes (cowpea) are inter-cropped with other food crops such as maize rather than grown as a sole crop. Thus, a one hectare of cowpea for example, may have many other crops on the same field. According to the data collected on adoption rate of introduced eco-farm technologies by farmers in ATJK district, among 32 household heads, 84.4% of the farmers (which is the highest) adopted the maize varieties and 59.4% adopted the new varieties of Haricot bean. Both new fruit crops and dairy goat production were adopted at a rate of 34.4 percent. The least adopted crop was new varieties of sorghum with 15.6% (Table 12).

TABLE 12 ADOPTION RATE OF INTRODUCED ECO-FARM TECHNOLOGIES BY FARMERS IN ATJK DISTRICT IN CENTRAL ETHIOPIA FROM PERCEPTIONS OF 32 HOUSEHOLD HEADS.

Eco-farm technology	**Response (%)**	
	Yes	No
New varieties of maize (*Zea mays* L.) crop	84.4	15.6
New varieties of haricot bean	59.4	40.6
New fruit crops	34.4	65.6
Dairy goat production	34.4	65.6
New varieties of sorghum (*sorghum bicolor* L.) crop	15.6	84.4

The lower score for adopting striga resistant sorghum attributes to the crop eating birds. The crop is susceptible to high level of attack from birds and need constant follow up. Hence the high labor cost associated with the three month life span of the crop demands more than they can afford. The continuous labor needed for at least three months to protect the crop from the crop eating birds was too much for the farmers to bear. Therefore, the farmers were agitated with the challenge of dealing with the birds. Following this hostile confrontation the number of farmers willing to adopt this particular kind of technology dramatically decreased.

ATJK is the area where two of the eco-farm participant farmers have got the role model awards from the district agricultural center. They, after joining the project, worked very hard and were able to accumulate wealth within short period of time. Therefore, from 32 members of sample household heads 53.1% of them had grade 5 to 8 education level (Table 4).We can say that their educational background helped them to seek for more information and decide on different levels than their counterparts. This is supported by the fact that 90.6 percent of them agreed on the negative effect of cultural beliefs of farmers against eco-farm technologies (Table 7). Besides, unlike the other district farmers, large number of farmers with a 93.8% of the total population considered for this research adopted more than four types of introduced technologies per year (Table 11).

Comparing to Tach-Armacheho, the maximum amount of farming land a farmer can have in ATJK was 5 hectare of land. This is three times less than Tach-Armacheho (Table 5). However,

the ATJK farmers got the highest amount of benefit from the adopted technologies. From the two most adopted technologies, highest benefit was received from new varieties of maize crop with 78.1 % and moderate benefit from new varieties of haricot bean. Though, some trees made it through the dry season, almost all adopted multipurpose and fruit trees were not yet ready for consumption. 52.6 % of those responded to have gained no benefit from the trees said that they have to wait for several years for the trees to give fruit. (Table 21)

In ATJK district finger millet was introduced for the first time and the use of the crop was very limited. Finger millet is one of the main grains in Tigray region which is normally dry planted and low input crop. It performs well in areas with low rainfall and is therefore drought tolerant. It is also used in Mekhone district as a local alcoholic beverage. Finger millet is entirely new to the Oromiya region district of ATJK. The feedback from the farmers was that they had little knowledge as to how to use the grain. Those who adopted finger millet for the first time harvested a few kilos and consequently they lost the motivation to do it again. Moreover, it is very hard to find the crop in the market because of its low market price. The demand for the crop at the time of data collection was observed to be very low. The research team could not even find it in one of the biggest Monday markets of the village.

Furthermore, this area, ATJK in Oromiya region, unlike the others has problems trusting the quality of the crops in the market based on my observation. Those who were included in the project saved crops for the next season by means of buying crops from the trusted places like that of nearby agricultural centers. ATKJ had more advantages over the others because loan facilities were provided by the governments. Government provides the introduced crops early in the beginning of each season with payment to be made after harvest up to two years after the project. However, for farmers who were unable to pay their loan at the end of the farming season, the government stopped giving loan service and made available cash sales only.

5.1.2 TACH- ARMACHEHO DISTRICT ADOPTION LEVEL

Tach-Armacheho is the place where farmers have enough size of land compared to the ATJK and Mekhone. A farmer can have a maximum of up to 15 hectors of farming land (Table 5). Many farmers in this area have large farm areas and possibly can produce as much as they want. However the shortage of human labor and the absence of farming machinery limited farm operations. Only some of them can afford to hire a daily laborer from the nearby town in the pick seasons.

In Tach-Armacheho district; new rice, finger millet and ground nut varieties were adopted at 67.6%, 48.6% and 37.8% respectively (Table 13). However, the sorghum variety (Gobye) was adopted at the lowest rate with only 29.7% of farmers willing to try it. In this area the most promising technologies adopted were rice, finger millet and groundnuts. The introduction of rice particular enabled the use of large idle land that has never been used for other crops. And it was suitable to the types of soil in the area, which is the most advantageous technology the farmers could get.

TABLE 13 ADOPTION RATE OF INTRODUCED ECO-FARM TECHNOLOGIES BY FARMERS IN TACH-ARMACHEHO DISTRICT IN NORTH WESTERN ETHIOPIA.

Eco-farm technology	**Response (%)**	
	Yes	No
New rice varieties	67.6	32.4
New varieties of finger millet	48.6	51.4
Sorghum variety (Gobye)	29.7	70.3
Ground nut varieties	37.8	62.2

Hence, the benefit of rice in this place was not only enabling farmers to use the un-used land, but also the usefulness of rice was much more than they expected. Along with additional introduction of food varieties to the farmers, rice had a whole lot of advantages to the farmers. Using rice for cultural alcoholic drinks in times of seasonal traditional holidays, cultural gatherings and celebrations became common. However, the main use of rice in this area was mostly for food. The local population learned the art of preparing rice in different dishes (ten different rice dishes to be exact). Rice proved to be very economical and highly beneficial for farmers with extended family members. Relatively small quantity of rice cooked is enough to serve several people. Moreover, earning money from selling rice in the market, exchange it with other necessary goods, and opening small business and selling rice made foods and drinks were the other extra benefits received.

Rice and groundnuts were the two most adopted technologies that brought lots of benefits for the local women in particular. The women in this area were not interested to work on the farm

rather, they were engaged in small businesses to make profits. They opened kind of cafeterias which offer groundnut tea, traditional alcoholic drinks made of rice and other businesses serving the local residents. Groundnuts, which provide a good alternative source of cash to women is a very popular newly adopted improved crop in the area. The crop was readily marketed as the demand exceeded supply. The women are more interested in embracing the crop because it opened a means of earning income to cover their own expenses. Few farmers have been grown groundnuts and used it previously. However it has become popular because eco-farm introduced groundnuts and they were aware of the health benefits more after its arrival. Most importantly, rice and groundnuts create job opportunity for the women in the area. Sorghum was the least adopted crop. Farmer's interest in sorghum was lower because of its low production and low market price. Therefore, once their expected level of output is not achieved, the crop was given little attention for further adoption.

Multipurpose trees like jatropha (Jatropha Curcas), kinin or neem (Azadirachta Indica), and shiferaw or Aleko (Moringa Stenopetala) and other local trees are available in most of the farmers' surrounding areas. The trees provide many benefits such as: income generation through the sales of seedlings to others, increased availability of products like firewood, charcoal, fruits, timber, poles, fodder and ornaments, wind breaks, help the environment by preventing soil erosion and increasing soil fertility. The trees also helped them to protect themselves from the burning and hot sun light.

A machine was introduced by the project to help the farmers with the rice production and quality. The introduced de-huller machine helps to separate the hard, compact seeds from the hulls. However, the machine depreciated and was out of use when the data was collected. Unfortunately because the machine was broken, most farmers tried to do the separation process using stones in the traditional way. One early and universal technique of transforming grain in to food is to mill the seeds slightly between two stones. This process reduces the quality of the rice and turns it into small pieces which led to a low price when delivered to the market. The fact that dehulled rice has higher nutritional quality farmers choose not to buy rice with its cover.

Unfortunately, it is problematic for investors to invest in the area because Tach- Armacheho has been known for lack of security for a long period of time. All the farmers have to carry a gun everywhere they go to protect themselves from rebel groups. Even though, the farmers themselves earn money from the sales of rice, they save their earnings rather than investing it.

They do not want to change the household appliances which can minimize the housework for the women. So far the living standard was observed to be the same in most households.

5.1.3 MEKHONE DISTRICT ADOPTION LEVEL

Mekhone was the area where the rain is not reliable and is of short duration. Farmers grow crops with short growing period. The adoption level was lower compared to the other districts. Before the introduction of the technologies, this area was highly susceptible to low rainfall. The climate change effect has its part on the change that has worsened through time. Currently farmers can produce only once a year. Thus, the arrival of the eco-farm project was considered as a life savior.

The farmers were motivated to adopt the technologies and work hard to change their lives. There were some doubts at the beginning, but after having seen the possible benefits that the project could bring them, the farmers started participating in the process to reduce the problem they encountered. They were eager to see the fast changes they had been told about. All the farmers emphasized that the technologies were easy to adopt, but with the persistent shortage of rainfall all what they had worked for was lost. The uncertainty of the future water supply makes the production and adoption harder through time.

Dairy goat production was introduced for divorced or widowed women. Dairy goats are improved breeds, bred for milk production. They are very different from local breeds and produce more milk. As for divorced or widowed women, the land they live on is not entrusted to them unless they live on and farm with the husband's family. In addition to being excluded from land and other natural resources, women have limited access to farm inputs. This is a special concern for women-headed households because their livelihoods and the sustainability of their land depend on such inputs. Dairy goat production requires less land, therefore it is considered to suit these women well. Unlike local breeds dairy goats are improved breeds for milk production which provide more milk rapidly. This made them beneficiary for the women to supplement their income. In the most parts of this area goats' milk can be sold for a better price than the price of cows' because of its medicinal use and content quality. This idea can be supported scientifically because the goats' diet is from leaves grown in the bushes

Different studies show that introducing dairy goat can improve human health and nutritional status. Adoption of dairy goat increases food availability, making it a potential means of achieving food security. Among adopters for dairy goat technologies was 27.3% adoption rate.

In spite of all the possible increase in income and nutrition level from dairy goat production, Farmers claim the reduction to adoption appears to be related to increase in infectious diseases.

The adoption rates in Mekhone district were not promising. According to the data collected, of all the adopted technologies, dairy goat production was the highest in percentage with 27.3% and both new varieties of haricot bean crop and multi-purpose trees were adopted with equal 12.1 percent of the farmers. New varieties of cow pea had the lowest adoption rate of 3 percent (Table 14). They have the perception that cowpea needs large area of land to grow. Therefore, with the shortage of farm land in Mekhone the farmers stopped growing it even though it was beneficial. Harvesting at physiological maturity was a way to harvest crops before it was too dry. The harvest normally takes place 10 or 15 days after the grain has reached physiological maturity. At that time of maturity the grain has specific moisture content and special physical characteristics. After harvest the stalks are used for the animals feed before it was too dray.

TABLE 14 ADOPTION RATE OF INTRODUCED ECO-FARM TECHNOLOGIES BY FARMERS IN MEKHONE DISTRICT IN NORTH EASTERN ETHIOPIA.

Eco-farm technology	**Response (%)**	
	Yes	No
New varieties of striga resistant sorghum	9.1	90.9
New varieties of haricot bean	12.1	87.9
New varieties of cowpea	3	97
Dairy goat production	27.3	72.7
Multi-purpose trees	12.1	87.9
New varieties of wheat	9.1	90.9
New varieties of maize	-	100

In this area, the most adopted technologies was maize, sorghum and moringa trees. Moreover, farmers also adopted technologies like fodder bank, mulberry and moringa trees. Striga resistant sorghum (Gobye) was widely adopted as well. Besides providing food for them, it is also used

for alcoholic beverages and as an important feed crop for chicken and livestock. Sorghum is one of the best sources of nourishment with the outstanding potential to withstand drought and high temperatures. Yet the fast growing crop has its own short comings; it needs constant follow up in order to protect it from the wild birds that attack in its early stage. Protection costs the farmers in human labor. When the farmers noticed the rain was going to delay, they decided to grow striga resistant sorghum because it can survive with small humidity at its early stage. A multipurpose tree such as moringa was distributed by the agricultural center and was observed to have been distributed to all the farmers in the area and other villages to. They used it for animal feed and it was available in most of the surroundings.

5.2 CONSTRAINTS TO ADOPTION

Table 15, 16, and 17 show the constraints for adopting each technology. The farmers' opinion is collected through focus group discussion and structured questionnaire. These constraints have been incorporated into the survey schedule using standards: "HIGH", "MODERATE", "LITTLE" and "NO" and ''I DO NOT KNOW''

TABLE 15 LEVEL OF CONSTRAINTS OF ECO-FARM PROJECT TECHNOLOGIES INTRODUCED TO ATJK DISTRICT FROM PERCEPTIONS OF 32 HOUSEHOLD HEADS.

Technology	**Level of constraint (% of farmers)**				
	High	Moderate	Little	No	I do not know
New varieties of maize (*Zea mays* L.) crop	9.4	15.6	34.4	34.4	6.2
New varieties of haricot bean	6.2	15.6	15.6	31.2	31.2
New fruit crops	3.1	3.1	3.1	9.4	81.2
New varieties of sorghum (*sorghum bicolor* L.) crop	6.2	9.4	6.2	3.1	75
New multi-purpose trees	3.1	9.4	-	6.2	81.2
Maize crop harvesting at physiological maturity	12.5	6.2	9.4	9.4	62.5
Fertilizer micro-dosing	6.2	12.5	9.4	12.5	59.4
Reducing tillage	12.5	3.1	9.4	-	75
Intercropping	-	6.2	6.2	15.6	71.9
Maize (*Zea mays* L.) seed priming	6.2	9.4	3.1	3.1	78.1
Dairy goat production	6.2	6.2	-	18.8	68.8
Bee keeping	25	3.1	-	-	71.9

TABLE 16 LEVEL OF CONSTRAINTS OF ECO-FARM PROJECT TECHNOLOGIES INTRODUCED TO TACH-ARMACHEHO DISTRICT FROM PERCEPTIONS OF 37 HOUSEHOLD HEADS.

Technology	**Level of constraint (%)**				
	High	Moderate	Little	No	I do not know
New rice varieties	16.2	24.3	18.9	5.4	35.1
New varieties of finger millet	24.3	13.5	16.2	2.7	43.2
Sorghum variety (Gobye)	10.8	5.4	2.7	-	81.1
Ground nut varieties	29.7	21.6	2.7	-	45.9

TABLE 17 LEVEL OF CONSTRAINTS OF ECO-FARM PROJECT TECHNOLOGIES INTRODUCED TO MEKHONE DISTRICT FROM PERCEPTIONS OF 33 HOUSEHOLD HEADS (IN PERCENT)

Technology	**Level of constraint (%)**				
	High	Moderate	Little	No	I do not know
New varieties of Striga resistant sorghum	12.1	15.2	6.1	6.1	60.6
New varieties of haricot bean	6.1	21.2	12.1	9.1	51.5
New varieties of cowpea	3	-	6.1	6.1	84.8
Dairy goat production	24.2	9.1	-	-	66.7
Fodder banks	9.1	12.1	9.1	3	66.7
Multi-purpose trees	12.1	12.1	9.1	3	63.6
Sorghum seed priming	12.1	6.1	6.1	6.1	69.7
Sorghum harvesting at physiological maturity	3	6.1	3	6.1	81.8
Stalk placement	6.1	3	-	9.1	81.8
New varieties of wheat	6.1	3	-	3	87.9
New varieties of maize	3	3	3	-	90.9

Several constraints were mentioned that limit the adoption of eco-farm technologies by the small holders in the three districts of Ethiopia. These are: lack of persistent rainfall, lack of education, backward farming practices, lack of an effective and efficient agricultural marketing system, high cost of inputs (such as: materials, fertilizers, labor), poor weather forecast, no price advantage for the products, less yield, lack of motivation to take risk, and the small piece of land are the basic problems on the adoption process. Accordingly, the discussions that took

place amongst the farmers, the observations and the survey collected pin point the main problems faced and the available challenges in adopting the agricultural technologies.

According to the structured questionnaire, lack of persistent rainfall (shortage of water) followed by high cost of input and size of land or non-fertility of farm land are the main constraints in all the three areas. The results in the table show that about 87.5, 100, and 84.8 percent of constraints are due to shortage of water in ATJK, Tach-Armacheho and Mekhone respectively (Tables 18, 19 and 20). High costs of input constraints were found to be 87.5, 78.8 and 48.6 percent, respectively. And all the other factors were important in their adoption decisions.

TABLE 18 MAJOR PROBLEMS AGAINST ADOPTING ECO-FARM TECHNOLOGIES BY FARMERS IN ATJK DISTRICT IN CENTRAL ETHIOPIA

Problems hindering implementation of new eco-farm technology	**Response (%)**	
	Yes	No
Shortage of materials/seed, labor, etc.	68.8	31.2
High cost of input materials/fertilizers, labor, etc.	90.6	9.4
Shortage of water	87.5	12.5
Shortage /or non-fertility/ of land	37.5	62.5
Lack of expertise	6.2	93.8
Time for training	-	100

TABLE 19 MAJOR PROBLEMS AGAINST ADOPTING ECO-FARM TECHNOLOGIES BY FARMERS IN TACH-ARMACHEHO DISTRICT

Problems hindering implementation of new eco-farm technology	**Response (%)**	
	Yes	No
High cost of input materials/fertilizers, labor, etc.	48.6	51.4
Shortage of water	100	-
Shortage /or non-fertility/ of land	51.4	48.6
Lack of expertise	18.9	81.1
Negative attitude	2.7	97.3
Time for training	2.7	97.3

TABLE 20 MAJOR PROBLEMS AGAINST ADOPTING ECO-FARM TECHNOLOGIES BY FARMERS IN MEKHONE DISTRICT

Problems hindering implementation of new eco-farm technology	**Response (%)**	
	Yes	No
High cost of input materials/fertilizers, labor, etc.	78.8	21.2
Shortage of water (drought)	84.8	15.2
Shortage /or non-fertility/ of land	12.1	87.9
Lack of expertise	24.2	75.8
Lack of applicability	3	97
Negative attitude	-	100
Time for training	21.2	78.8

5.3 WHAT FACTORS WERE IMPORTANT IN THE FARMERS ADOPTION DECISION?

The objective of adoption surveys (quantitative) and focused group discussion (qualitative) and of this paper is to show which factors were important in their adoption decision. Each factor affects the adoption process significantly. Factors that may affect the level of use of the technology and its acceptance by the farmers include: characteristics and advantages of technology, users of the technology, representatives of the introduction of technology such as propagators and professionals and social, economic, biological, physical and environmental conditions in which technology is used (Cruz, 1978).

5.3.1 LACK OF PERSISTENT RAINFALL (DROUGHT)

Since water is fundamental for survival, it is also essential for farmers who entirely rely on agriculture. Almost all the farmers in the three regions had faced the challenging task of dealing with the absence of rainfall. Understandably, most farmers agree on the absolute importance of water (in this case rain fall) for the farming system.

In Tigray region, Mekhone district, before the introduction of Eco-farm Project there was drought for four successive years. The adoption process is slowed significantly by the absence of rain. For farmers who are dependent on the natural rainfall, with no other means or sources of water, introducing new drought resistant crops and soil management like conservation tillage will not be the only solution to reduce the farmers' vulnerability to the effect of climate change. Farmers are constrained by inadequate rain fall situation and unable to adopt the introduced technologies. The scarcity of water is getting acute from time to time and it is becoming difficult to cultivate even once in a year. Even though the objective was to help farmers deal with the effect of climate change, the water problem was the most critical problem in these areas. The vulnerability of the farmers to the uncertain future needs more emphasis. The introduced technologies can be adopted if the water problem is solved. The discussion group said '' it would be better for them if the project introduced drip irrigation system and irrigation facilities so that they can exploit the nearby river and grow different kinds of crops, vegetables and the newly introduced multipurpose trees and fruits at any time of the year without waiting for the rain to come''. This may tackle the food shortage in times of dry season and increase the nutritional level of the farmers and their families.

5.3.2 LACK OF EDUCATION

Farmers' problems to adopt new agricultural technologies can be seen in different ways. One of the challenges that farmers are facing is lack of education. Most farmers in the selected three areas were considered to have lower level of education. According to the data collected, out of 32, 37, and 33 farmers, the illiteracy rate was 3.3, 45.5, and 37.8 percent in ATJK, Mekhone, and Tach-Armacheho respectively. Comparatively, ATJK district had the highest percentage of educated farmers. 53.1 percent of them had between 5 and 8 grades unlike the district of Mekhone which is 6.1 percent and Tach-Armacheho 10.8 percent only (Table 3). Therefore, 93.8% ATJK district farmers tried to adopt four and above technologies in one year. This by far exceeds the other two districts. According to the focus group discussion in Tigray region, farmers with a lower level of education were the least adopters of newly introduced technologies. In a discussion we had with the farmers, there were some crops they totally avoided from growing. Haricot bean was one of the avoided crops. The reason behind the refusal of this crop is the thought that eating haricot bean eventually may damage the body. This crop is traditionally considered harmful and is assumed that it permanently damages the bone of the leg when fed for a long time. This misconception was so pervasive that I too, as a child, had the belief that this specific crop paralyses the body. Hence, categorizing the crop as a dangerous crop to eat and rejecting to adopt it, is a reflection of lack of education. In other words, this kind of stand points can clearly be amended if the farmers get an opportunity to education. Such views have passed on from generation to generation and have created problems .By the same token we also noticed farmers who believe a crop that releases a strong smell when cooked can be harmful to the body.

Unfortunately, in ATJK district introduction of finger millet was not welcomed. It was neither used for consumption nor for cultivation. The reason farmers gave was that they do not know how to make food out of it. In addition, no matter how the crop is suitable to grow in the area, they do not find reasons to grow it because of lack of market.

Exchange of ideas among the farmers of the three regions can bridge the gap on their attitude towards the crop and what they can do with it. This crop is widely grown in Mekhone district and mostly used to make a local alcoholic drink called '*t'ella*'.

Education can assist farmers accepting and adopting technologies. Farmers' lack of education prevents them to actively participate in the adoption process. Technology adoption is not a onetime action, but a long-term process. The low level of education makes it difficult for them to understand the benefits of the technologies and to use them the farmers have traditional

beliefs that negatively effect on the technology adoption process. There high level of education makes the farmers more willing to take risks, Reasons for not using and accepting new technology by farmers include lack of belief in newly introduced technologies in agriculture, lack of consideration of different dimensions of technology, fear of low performance of the newly adopted technology, low education, elderly farmers who lack belief in new technologies, the use of traditional methods of cultivation by farmers and farmers with large lands (Thinegoc chi and Yadama, 2002).

5.3.3 LACK OF INFORMATION ABOUT THE LEVEL OF RAINFALL

While the persistent lack of rainfall becomes unavoidable at times, lack of information about the level of rainfall was also problematic to the farmers in their preparation. Weather forecast information was never given and the lack of this important information affects the production and adoption decision of the farmers. Every year, the farmers prepare themselves for cultivation without knowing the expected level of rain for the season. They were relying on the mere facts that the drops of rain could save them from hunger. They cannot plan in advance what kind of crops to sow. Poor weather forecast or the unavailability of information puts the farmers in a very desperate situation. Normally farmers are always ready right before the cropping season. They have got very short period of time between the arrival of the rain and the cropping season in which farmers have to rush for decision. They desperately need the weather forecast to decide which crop to grow in case of early rainy season and late rainy season.

Lack of accurate insight into exactly how their farm lands behave can also affect the adoption process in many ways. On one hand, they may end up losing the good rainy season assuming the same dry season may come again. On the other, they may exhaust their resources during the drought season expecting for a wet one. When I was in the field, many farmers did not grow rice because they thought that the same dry season may arrive and they may lose everything again; though it happened to be a good rainy season and they were not ready to grow rice. Farmers mostly face a problem when the rain comes too late after they put all their efforts on cultivating and cropping. Hence, the probability of losing all may be higher. Most of the time the farmers tried to deal with the uncertainty of the future weather condition by saving most of the harvested crop for consumption in case of drought. No motivation to increase farming areas with the expectation of good rainy season and also not interested to take the risk of putting all the effort on the farming, tillage and sow all the crops at hand. However, they wanted to be informed about the level of rainfall, if it comes sooner or later, and they said they need advice

on what kind of crop to sow in different situations. Information about the upcoming rainfall minimizes risks. Therefore, it is crucial for the farmers to have access to weather forecasts in order for them to decide on the adoption process. There is a weather prediction available in the media like TV and radio.

5.3.4 CONSEQUENSES OF TRADITIONAL FARMING PRACTICES

Traditional farming practices are considered to be one of the main causes of reduction in the harvest and adoption process for the farmers. The use of new technologies basically goes hand-in-hand with the farming techniques and mechanisms practiced. Hence the traditional farming practices cost them excessive amount of time and energy in the good rainy season. Although in Tach-Armahecho a farmer can have a maximum of 15 hectare of land compared to five hectares in ATJK and one in Mekhone (Table 5) farmers in ATJK did well on the adoption process. Those farmers who have large size of farming land did not use it to its full capacity because of the poor farming practices. The urge for new farming machineries to facilitate cultivation in the rainy season and at the same time reducing high labor cost was a wish of the farmers.

The traditional farming practice not only hinders them from adopting different technologies at a time but also affects production level in good seasons. In spite of the small sized land they have, they tried to apply the introduced farming management technologies such as inter-cropping, reduce tillage and so on. But some of the crops need more place to grow. Intercropping cowpea with the main crop in such small piece of land was problematic. Farmers claimed cowpea needs a large area to grow. However, even those who have larger farming lands couldn't cultivate with full capacity because of the ineffective farming practice. The time spent starting from cultivating the land up to harvesting needed a huge amount of hard labor to be invested.

5.3.5 LACK OF MOTIVATION TO TAKE RISK

The lack of education level and weather forecast accompanied with lack of motivation reduced farmers' willingness to take risks. Farmers need motivation in order to take a risk for the newly accepted technologies. Farmers are sensitive to taking risks and they avert risk as much as possible. However, the level of yields is still an important adoption determinant. Crops with lower yield levels are much more unlikely to be produced on the next production. The low production often times associated with the failure of the technology. They were easily

discouraged after the poor outcomes of any new crop. Crop rotation can reduce risk. If yield of a crop is low in one year, the farmers are not likely to plant it. Removed because of bad English

5.3.6 LACK OF AN EFFECTIVE AND EFFICIENT AGRICULTURAL MARKETING SYSTEM

Farmers face problems with the quality of improved seeds in the market. Even if improved seeds are available in some areas, their quality tends to be inferior due to frequent mixing of types of seeds. Improved are mixed with un-improved ones, different varieties of improved seeds mixed together, healthy seeds mixed with disease-infected seeds, and lack of proper labeling to indicate which variety farmers are purchasing. Production and sales of improved seed also give us a good indicator of adoption of new varieties. Because the fluctuating price for the crops in the local market discouraged the producers.

For instance tools such as herbicides, insecticides, and fungicides reduce crop losses both before and after harvest. The harvested crops must be stored until the price rises. Storage facilities under traditional crop storage practices make the crops susceptible to different kinds of pests such as: weevils, vermin, rats, mice, insects, mold and fungi.

The quality and quantity of the crops can only be preserved if exchange of crops occurred between farmers who knew each other. To tackle the marketing problems, they were insisting on having cooperation or small farmers groups with the help of the government. This motivates the farmers to produce much more, which can result in an increase in output of primary commodities and can lead to increased demand of manufacturing industries.

5.4 BENEFITES TO ADOPTION

The farmers in the three areas were motivated to adopt the introduced technologies in their farming activity based on the awareness regarding the benefits of the technologies. This awareness coupled with the simplicity of the technology helped farmers to progress in the adoption process. Although, there were other important factors influencing their decisions to adopt the new technologies, the potential benefit from the technologies was understandably the main motivation for them. All in all the benefit (*Note that the term benefit here means any kind of benefit received either as used for consumption purpose or sold in the market*.) received was evaluated for each and every technology. Hence, farmers were asked to rank each adopted technology in three levels: high, moderate, and little. In ATJK district farmers rated the new

varieties of Maize to have the highest benefit with 78.1%, followed by moderate benefit from new varieties of haricot bean with 43.8%, and little benefit from Maize crop harvesting at physiological maturity with a 62.5% (Table,21).

TABLE 21 LEVEL OF BENEFITS OF ECO-FARM PROJECT TECHNOLOGIES INTRODUCED TO ATJK DISTRICT

Eco-farm technology	**Level of benefit (%)**				
	High	Moderate	Little	No	I do not know
New varieties of maize (*Zea mays* L.) crop	78.1	-	6.2	9.4	6.2
New varieties of haricot bean	9.4	43.8	3.1	12.5	31.2
New Fruit crops	-	-	34.4	9.4	56.2
New varieties of sorghum (*sorghum bicolor* L.) crop	3.1	12.5	12.5	3.1	68.8
New multi-purpose trees	-	6.2	56.2	6.2	31.2
Maize (*Zea mays* L.) crop harvesting at physiological maturity	3.1	6.2	62.5	12.5	15.6
Fertilizer micro-dosing	-	9.4	75	3.1	12.5
Reducing tillage	-	3.1	25	9.4	62.5
Intercropping	-	9.4	56.2	12.5	21.9
Maize (*Zea mays* L.) seed priming	-	-	21.9	9.4	68.8
Dairy goat production	3.1	3.1	18.8	6.2	68.8
Bee keeping	-	3.1	6.2	12.5	78.1

In Tach-Armacheho district, the benefit of new rice varieties were ranked high by 51.4% followed by new ground nut varieties ranked moderate by 32.4%, and new varieties of finger millet ranked little by 24.3% (Table, 22). In Mekhone district dairy goat production had the highest benefit with 27.3%, new varieties of Striga resistant sorghum moderate benefit with 18.2%, and fodder bank ranked little with 9.1% benefit received (Table, 20).

TABLE 22 LEVEL OF BENEFITS OF ECO-FARM PROJECT TECHNOLOGIES INTRODUCED TO TACH-ARMACHEHO DISTRICT IN NORTH-WESTERN ETHIOPIA

Technology	**Level of benefits (%)**				
	High	Moderate	Little	No	I do not know
New rice varieties	51.4	8.1	5.4	-	35.1
New varieties of finger millet	29.7	13.5	24.3	2.7	29.7
Sorghum variety (Gobye)	2.7	10.8	-	5.4	81.1
Ground nut varieties	16.2	32.4	13.5	-	37.8

TABLE 23 LEVEL OF BENEFITS OF ECO-FARM PROJECT TECHNOLOGIES INTRODUCED TO MEKHONE DISTRICT IN NORTH-EASTERN ETHIOPIA

Technology	Level of benefits (%)				
	High	Moderate	Little	No	I do not know
New varieties of striga resistant sorghum	15.2	18.2	3	-	63.6
New varieties of Haricot bean	12.1	15.2	3	9.1	60.6
New varieties of cowpea	3	-	6.1	6.1	84.8
Dairy goat production	27.3	9.1	-	-	63.6
Fodder banks	3	18.2	9.1	6.1	63.6
Multi-purpose trees	6.1	9.1	9.1	6.1	69.7
Sorghum seed priming	6.1	15.2	3	6.1	69.7
Sorghum harvesting at physiological maturity	3	3	6.1	6.1	81.8
Stalk placement	6.1	-	-	9.1	84.8
New varieties of wheat	6.1	3	3	-	87.9
New varieties of maize	6.1	-	3	-	90.9

Those positive attitudes towards the introduced technologies were essential for the households in those three districts. If the benefit outweighs the constraints, the likelihood to adopt new technologies will increase. As expected, those farmers who do not believe in the technology adopted to a lesser degree. The major advantages of eco-farm technologies to households in those three districts are listed accordingly: increase productivity, increase income, conserve energy and time, increase savings, improves food security and the likes. (Table 24, 25, 26)

TABLE 24 MAJOR ADVANTAGES OF ECO-FARM TECHNOLOGIES TO HOUSEHOLDS IN ATJK DISTRICT IN CENTRAL ETHIOPIA

Advantages due to introduction of the new eco-farm technology	**Response (%)**	
	Yes	No
Increase productivity	84.4	15.6
Increase income	71.9	28.1
Conserves energy and time	28.1	71.9
Increase savings	12.5	87.5
Improve food security	75	25
Other advantages	15.6	84.4

TABLE 25 MAJOR ADVANTAGES OF ECO-FARM TECHNOLOGIES TO HOUSEHOLDS IN TACH-ARMACHEHO DISTRICT IN NORTH-WESTERN ETHIOPIA

Advantages due to introduction of the new eco-farm technology	**Response (%)**	
	Yes	No
Increase productivity	89.2	10.8
Increase income	73	27
Conserve energy and time	35.1	64.9
Increase savings	27	73
Improve food security	75.7	24.3
Other advantages	35.1	64.9

TABLE 26 MAJOR ADVANTAGES OF ECO-FARM TECHNOLOGIES TO HOUSEHOLDS IN MEKHONE DISTRICT IN NORTH-EASTERN ETHIOPIA

Advantages due to introduction of the new eco-farm technology	**Response (%)**	
	Yes	No
Increase productivity	69.7	30.3
Increase income	27.3	72.7
Conserve energy and time	27.3	72.7
Increase savings	12.1	87.9
Improve food security	27.3	72.7
Other advantages	9.1	90.9

As a result, 84.4, 89.2, and 69.7 percent of farmers in ATJK, Tach-Armacheho and Mekhone respectively were highly motivated by increased production. The increased productivity of crops is the main reasons to adopt the crops. There have been many studies which have examined the factors influencing the adoption of technology by farmers. Especially in less developed countries, the adoption of new technology in agriculture has attracted considerable attention from economists and technology diffusion paradigms point of view. Majority of the less developed countries population depend on agricultural production and new technology seems to offer an opportunity to increase production and income substantially (Feder *et al. 1985*).

Hence, the level of yields was an important adoption determinant to keep growing the same crop every year; which meant that the higher the production, the greater the likelihood that the new crop will be produced next year. However, the production is very dependent on the rainfall during the crop season. Crops with lower yield levels are unlikely to be produced in the following year. There were times when all of the farmers took the chance to produce the introduced crops and then they became easily discouraged because the outcome was not as they expected. The varying use of crops from year to year was meant to reduce the risk of low production. However, there was no other option but to wait for the rain fall. Since the farmers

believed that new technologies always succeed and are profitable, the low production possibly comes as a surprise to them. Hence, the level of risk they wanted to take for the next season would be less than the one they took before. The fact is, the low harvest also happened to the crop they have been producing for a long time, but they hardly noticed it.

In line with the data collected, increase in productivity was the most important determining factor concerning which crop to grow the next season. Accordingly, the production level determines how many technologies the farmers wanted to adapt and which one of them to choose right after the harvest.

On the other hand, the second most sited advantage received that trigged farmers to go forward with the adoption process was improved food security. As a result, 75% of farmers in ATJK, 75.7% of farmers in Tach-Armacheho, and 27.3% of farmers in Mekhone districts claimed to have gained increase in food security (Table 10, 11, 12). The result seems to explain the commonly understood principle that higher crop production correlates with greater food security. According to refined definition by World Food Summit ‘‘food security exists when all people at all times have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life’' (WFS,1996). The food security in this context denotes an increase in food consumption and an uptake in the availability of food supply in the stores for consumption at any given time. It also indicates the introduction of new crops with improved nutritional quality compared to previous times. The benefit received can be summarized as an increase in food choice for daily consumption and the quantity of available food throughout the year until.

In addition to that, the introduction of technologies benefited farmers in lots of other ways. Those who were not eating once a day were able to eat twice daily. Those who were not having enough food was able to save some for future crises and those who were not sending kids to school were able to afford to pay for their kids' entire school expenses and satisfy all the basic needs of their families. There were farmers who built new houses and small hotels, expanded the land size and even some of them accumulated wealth and opened small shops which created jobs for others. The socio-economic status of women who used the new technologies was improved as well dramatically. The change brought to women farmers were the most important that can be sited here. Female farmers developed the feeling of being secured and were increasingly motivated to participate and engage themselves in the decision making process within their families. They involved themselves in a small business activity and started to make profit. It reduced the women’s dependence on their men as the sole bread winners and helped

them to contribute to the economics of the household. They could also decide to send their kids to schools and help their family members financially. The women in Mekhone and Tach-Armacheho, in particular, were socially and economically advantageous in the whole adoption process. Previously dependent women were somehow able to free themselves from financial dependence.

The third most advantage was an increase in household income. Tach-Armacheho district is the lead in this category with 73% of farmers in that district claimed to have gain an increase in income from a sale or exchange of their crops in the market place; ATJK district follows with 71.9%, and Mekhone district had the least of all with only 27.3% of its farmers claimed to have an income from crop sales (Table 10,11and12). The increase in income is usually calculated by deducting the total sales of individual crop from the total expenses of individual crops. However, the percentage above was calculated based on number of farmers answering YES or NO to the question about increased income.

5.5 EXPENDITURE AND INCOME FROM THE INTRODUCED TECHINOLOGIES

Expenditure includes cash payment for any kind of expenses such as seed, labour and fertilizers and other costs of production. Due to differences in soil potentials, quantity of inputs used and other factors production costs will vary from farm to farm. Labor has been treated as a fixed cost since farmers used their own labor. However, labor cost is considered if it is paid for. Income on the other hand includes income in cash that comes from the selling of products that must be sufficient to pay cash costs including seed, fertilizers and other costs of production.

Due to data constraints, the effects of income and expenditure have not been analyzed in detail in this paper. The buying and selling process goes on throughout the year and there was no record of transaction on how much sold and how much consumed. Besides, those areas include small urban areas with minimum sized cities around them. The involvement of villages or towns in regional, national and international markets for inputs, products and labour in activities and local market is very small. Even though some technologies may increase yield, the gains may not be high enough to cover the expenses. In order for them to sell the crops left from consumption they need to make an extra effort to work on the quality of the crops. The very reason for the lack of separation of income from sale and consumption is that it was not possible to know how much was sold and how much was consumed from the total output.

Furthermore, the cost expenditure on inputs explained money spent on inputs. Hence, the data collected gave two options for answer: YES if they spent cash and NO if they did not. Table 27, 28 and 29 shows the proportion of farmers who responded to the estimated expenditure on inputs of eco-farm technologies introduced in the three districts respectively. The cost in this term specifies only money paid in the process of cropping until the harvesting time. Accordingly, in ATJK district 93.8 percent of farmers incurred costs (money paid) to adopt the new varieties of maize. The rest 6.2 percent responded no money spent on the crop. In Tach-Armacheho district 64.9% of farmers claimed to have paid money in order to adopt the new rice varieties and the rest paid nothing. In Mekhone district 15.2% claimed to have incurred some costs for dairy goat production and the rest 84.8% had no cost at all. The logic behind this was that expenditure was to be considered as cost for buying crops or hiring labor. The crop exchange culture between them mostly minimizes the cost and the use of own labor was not considered as money spent.

TABLE 27 EXPENDITURE PAID ON INPUTS OF ECO-FARM TECHNOLOGIES INTRODUCED TO ATJK DISTRICT IN CENTRAL ETHIOPIA

Cost expenditure on inputs	**Response (%)**	
	Yes	No
New varieties of maize (*Zea mays* L.) crop	93.8	6.2
New varieties of haricot bean	59.4	40.6
New fruit crops	-	100
Dairy goat production	6.2	93.8
New varieties of sorghum (*sorghum bicolor* L.) crop	6.2	93.8

TABLE 28 EXPENDITURE ON INPUTS OF ECO-FARM TECHNOLOGIES INTRODUCED TO TACH-ARMACHEHO DISTRICT IN NORTH WESTERN ETHIOPIA FROM PERCEPTIONS OF 37 HOUSEHOLD HEADS

Cost expenditure on inputs	**Response (%)**	
	Yes	No
New rice varieties	64.9	35.1
New varieties of finger millet	51.4	48.6
Sorghum variety (Gobye)	24.3	75.7
Ground nut varieties	32.4	67.6

TABLE 29 EXPENDITURE ON INPUTS OF ECO-FARM TECHNOLOGIES INTRODUCED TO MEKHONE DISTRICT IN NORTH EASTERN

Eco-farm technology	**Response (%)**	
	Yes	No
New varieties of striga resistant sorghum	6.1	93.9
New varieties of haricot bean	9.1	90.9
New varieties of cowpea	-	100
Dairy goat production	15.2	84.8
Multi-purpose trees	9.1	90.9
New varieties of wheat	6.1	93.9
New varieties of maize	-	100

Furthermore, benefits of eco-farm technologies to farmers are presented in two categories. Farmers who adopted technologies and used all the harvested crops for household consumption purpose and farmers who used proportion of harvested crops for sale. Because most farmers cannot recall how much income was earned from the crops the data was collected in two categories. The first category is 'household consumption' which represents farmers who used the total harvested crop only for household consumption. And the second category is 'consumption and money' which represents part of the harvested crop which was sold in the market.

TABLE 30 BENEFITS OF ECO-FARM TECHNOLOGIES TO FARMERS IN ATJK DISTRICT IN CENTRAL ETHIOPIA

Eco-farm technology	**Benefits from eco-farm technologies**	
	Household consumption	Consumption and money
New varieties of maize (*Zea mays* L.) crop	21.9	56.2
New varieties of haricot bean crop	25	31.2
New fruitcrops	3.1	-
Dairy goatproduction	-	6.2
New varieties of sorghum (*sorghum bicolor*L.) crop	6.2	3.1

TABLE 31 BENEFITS OF ECO-FARM TECHNOLOGIES TO FARMERS IN TACH-ARMACHEHO DISTRICT IN NORTH-WESTERN ETHIOPIA

Eco-farm technology	**Benefits from eco-farm technologies**	
	Household consumption	Consumption and money
New ricevarieties	2.7	59.5
New varieties of finger millet	21.6	32.4
Sorghumvariety (Gobye)	13.5	13.5
Ground nut varieties	10.8	24.3

TABLE 32 BENEFITS OF ECO-FARM TECHNOLOGIES TO FARMERS IN MEKHONE DISTRICT IN NORTH EASTERN ETHIOPIA

Eco-farm technology	**Benefits from eco-farm technologies (in percent)**		
	Household consumption	Consumption and money	No benefit
New rice varieties	2.7	59.5	37.8
New varieties of finger millet	21.6	32.4	45.9
Sorghum variety (Gobye)	13.5	13.5	73
Ground nut varieties	10.8	24.3	64.9

5.6 REASONS FOR ADOPTION AND REJECTION OF TECHNOLOGIES.

Some components of technologies were adopted while leaving out other recommended practices. However, there is a need to better understand why some farmers adopt and why others not. Classifying farmers as adopters or non-adopters failed to shed light on the adoption process. Rather, a multistage decision processes appeared to occur in which farmers moved from learning to adoption and then to continue or discontinue the use of technologies. Technology adoption is not a matter of a one-time decision leading to continue to use the technology. A relatively long period of time may be required for farmers to adopt a new technology, even for the one that is demonstrably profitable for them. It is critical to understand both farm and farmer characteristics that are likely to affect the level of adoption of new technology. This study was motivated by the need to identify the socioeconomic and institutional factors that influence the adoption techniques.

The findings shows that Mekhone district farmers were the lowest adopters among the three sites. In the focus group discussions held with farmers, they cited list of reasons to adopt or not to adopt the technologies. The main reason for adoption was the expected increased production. However, the variability in yield was related to variability in both rainfall timing and rainfall level. The limited access to irrigation resulted in extreme crop yield risks. The level of input use has to be decided before the rains have come and the harvest is known, thus new technologies are considered risky investments. While average yield will exceed that of traditional seeds. Improved seeds returned very low yields in consecutive years farming seasons resulting low output. In addition to variability in the weather, farmers were exposed to various crop diseased, pests and animal mortality due to infectious dairy goat diseases. Farmers in the areas are risk averse. However farmers also face external constraints like credit constraints mainly because of lack productive assets which are acceptable as collateral. *Rogers, 1995* stated that most people are afraid of adopting new innovations due to the fear of unknown future risks. Farmers are not sure about the level of risk they should take.

Snapp *et al.*1998 noted that the slow growth of trees make their effects and rewards difficult to observe; this could have resulted in low adoption among farmers. Farmers with low education level and of old age farmers did not believe in the new technologies and only believe their own experience. Age is an important factor that influences the probability of adoption of new technologies because it is said to be a primary latent characteristic in adoption decisions. The

younger farmers suggested that younger farmers are more eager to try new technologies. In addition they said they have a low risk aversion and longer planning horizon to justify investment in technologies whose benefits are realized over a longer period of time. But despite these gains, older farmers in Mekhone continue to lag behind younger farmers. As farmers grow older, they become more skillful through learning by doing. But this trend weakens as they reach middle age and their physical strength begins to decline. Also, with age, farmers become more risk averse and less willing to adopt new farming technologies. Shortage of retail markets is also constraining farmer's initiative to expand the practice. The absence of help provisions of agricultural inputs and the need to encourage participation of local retail outlets in providing seeds and fertilizers that are necessary for farmers who are practicing.

6 WHY ARE SOME TECHNOLOGIES ADOPTED AND OTHERS NOT

It is widely known that the adoption of innovations by farmers in developing countries is frequently gradual and incomplete. Agricultural technology adoption shows that diffusion of new technologies varies significantly across space and time. Uncertainties exist about why some seemingly profitable technologies that would improve productivity and farm incomes are not adopted. Hence, understanding the adoption and diffusion of new agricultural technologies can be quite useful in promoting the spread of new technologies in poor countries.

Culture seems to matter, though, as with villages, the paths by which culture affects adoption remain unclear. I have presented two ad hoc reasons for why some technologies are adopted others not. It is mostly associated with the conception that lower production leads to lower adoption. But the puzzle merits a theory of adoption before conducting more technology diffusion. Awareness is necessary but not enough impetus for adoption and there might be factors outside of farmers' control affecting their decision to adopt. Some authors reported that farmers do not adopt sustainable agricultural practices even after they are aware of the negative consequences from conventional agriculture. For instance soil management activities like conservation tillage was introduced to traps soil moisture to improve water availability and minimizes the loss of organic matter and protects the soil surface with plant residues however farmers totally rejected the technology even if they are aware of the benefits. Farmer's reason for their unwillingness to adopt conservation tillage is that they think that it was not useful and did not believes it works well with the soil type. In ATJK district those who discontinued honey bee keeping said that the demands of the technology was difficult to meet and were not feasible to continue.

Furthermore technology spreads through social system. Many farmers agreed that it was not easy to get accepted by fellow farmers and the community in general. One farmer in ATJK said that ''what others think matters to me.'' The most important drive that potential adopters consider in the adoption decision process is what they think others contemplate about the innovation. In other words, potential adopters are greatly influenced by opinions within their social networks.

Most farmers do not expects poor farmers to be sources of innovators. Many farmers have the tendency to believe that it is only the so called literate and intellectual people (like the extension

workers) who could bring something new and important to the farmers. The always believe contact with extension services gives farmers access to information on innovations, advice on inputs and their use, and management of technologies. They do not dare to ask for help from their fellow farmers. Even if they did they need conformation from the extension workers. In most cases, extension workers establish demonstration plots where farmers get hands-on learning and can experiment with new farm technologies. Consequently, access to extension is often used as an indicator of access to information (Adesina *et al.* 2000; Honlonkou 2004). Rogers, 1983 suggested that there is a small percentage of early adopters. These individuals tend to have higher socioeconomic status, have broad access to communication, are more likely to be literate, tend to be more intelligent, and have higher capacity for uncertainty for change. Though farmers perceived technology as useful thing to them, they still faced problems in application of technologies. These include lacking of capital. Moreover the personal characteristics of extension workers such as having good relationship with farmers and ability to communicate with farmers influence the adoption to some extent.

6.1 ADOPTION PROBLEMS *RELATED* TO THE FARMERS PERCEPTION

Despite their great enthusiasm to try new things, many farmers are constrained with resource limitations, apparently not able to take risks and carry out experiments with their meagre resources. However, there are two main problems related to farmers' behavior that was important in the adoption process. Farmers are dependent on aid. Those areas are continuously affected by drought and they have been places where aid was given for so long. The government with the help of aid agencies distributed food to the affected areas whenever there is food shortage and drought. The continuous aid has caused the dependency on aid and farmers' attitude towards being resistance to change. Consequently, farmers' dependence on the food aid hindered their motivation to work hard during the good rainy seasons. Erroneously they assume that every project comes to give an aid and not to assist them to overcome the existing problem. During my field work, many of the farmers asked me when would be the project's second visit. They developed the habit of expecting from others and depending on others. To cite one example here, the government established a way to distribute the collected crops from the farmers back to them on fair prices. For those who cannot pay in cash, the government offered them loans so that they will pay after their harvest. However, they did not want to pay the loans. Consequently, the government stopped providing crops to the farmers on credit. The farmers sought assistance for longer period of time than they really needed. Some of them even want

the project to sustain forever providing continuous service. Especially in Tigray region, the continuous droughts have made farmers reliant on aid. The second point is farmers' resistance to change. Low level of education is one reason. Aid given in kind for so long has created a mind-set of not considering aid in terms of ideas, information and technology. They were very much interested in my arrival for the data collection for they thought that there was something to be given or distributed afterwards. This is one of the reasons why farmers opt to stick to the traditional experience of doing agriculture or simply wait and see what the extension agents will come up with.

In addition to this, farmers adopt the technology for short while until the project's departure. Hence, they were picking pieces of information rather than accepting the whole system. They were using the project as a means of income or taking the opportunity until the project is completed. Some of the farmers joined the project for the sake of quick benefit not for the long-time advantage it brought to them. This is contrary to the project idea "give one a fish so that one can dine for a day, but teaches one how to fish so that one can eat for life time".

6.2 ADOPTION PROBLEMS ASSOCIATED WITH THE PROJECT

The project, as any genuine developmental project, had the intention to help the poor farmers in need of assistance. The unique feature of this project is its readiness to help the poor before any disaster. Unlike the other donors that only donate in times of critical stage or in a time of worst situations to portray themselves as heroes or saviors in the eyes of the world. As the saying says *as a 'crisis savior' in the time of famine or disaster*. This project was the first one to take into consideration the vulnerability of the areas to climate change effects. As the project had many positive contributions on the lives of the farmers, it also had many shortcomings.

6.2.1 INTRODUCED TECHNOLOGIES WITH UN INCOMPLETE EQUIPMENTS FOR A STARTUP

All the needed agricultural machines and equipments should, as far as possible, be found locally and their affordability, availability, maintainability and manageability need to be ensured. Any technology appropriate for small holder should be simple in operation and easy to understand. *Nowak, 1991* explained that one of the reasons farmers became unable to adopt residue management techniques is the lack of information regarding economic or technical issues of these technologies.

Furthermore, adoption of a new technology is often very costly for various reasons. Some of the introduced technologies did not have all the necessary components. Three technologies can be cited here. The first one is bee keeping. It was listed on the introduced technology in the ATJK and Tach-Armacheho districts but in actual facts, as I myself observed, only incomplete bee houses, which stood still doing nothing, were distributed to some of the farmers. The second was dairy goat production. It was introduced to few widowed women in Mekhone. No medicine was available around their village and the animal clinic is located very far from the settlement which led to the loss of the widowed women. The third one was rice dehuller machine. In Tach-Armacheho rice was the most beneficiary and promising crop. It is widely accepted by the farmers and can be referred to as one of the best successes of the project. This new crop built up the nutrition level of the farmers and at the same time increased food security. The introduction of rice in this area helped the farmers to use the land that was idle before. The farmers wanted to cultivate rice in full capacity, but they faced a major problem. The rice does not have demand in the market if it is not separated from its cover (husk). There was only one machine for all the villages in the area and it broke down.

6.2.2 INEFFECTIVE SCALING UP WORK

The term 'scaling up' is much used by the development projects. Similarly, the Dryland Coordination Group project used the same action escalating technologies introduced in the three parts of the country. Scaling up process failed in Tigray and Oromiya. Especially in Tigray region, it can be said that the project failed to attain the objectives. The given explanation as the main cause for the scaling up failure was drought. Although the three regions are known as dry lands, there are variations on the degrees of vulnerability. Almost the same technologies were invariably introduced in the three regions with the same duration of time. The last one year of the project was used for scaling up the experimented technologies. However, the scaling up failed in two regions because of shortage of rain.

6.2.3 LACK OF CREDIT FACILITIES

A hypothesis that is often raised in the literature is that credit constraints explain the lack of adoption. A study made in Ethiopia estimated a double obstacle fertilizer adoption model for farmers using self-reported information on why farmers did not purchase fertilizer. They found that credit is a major supply side constraint to adoption (*Demeke. et. al, 2003*).Access to credit is important to farmers. The government agreed to take the responsibility of distributing

technologies that were advantageous to the farmers such as maize and rice. The regional agricultural administration in the three regions tried to distribute the crops through cash support and loan. ATJK district were advantaged with loans. However, at the time of data collection, the government stopped giving loans. This was a disadvantage for those who needed to use the new crops, but did not have cash at hand to pay on delivery. Farmers have accumulated unpaid loans for more than two years. They needed cooperation with the government to form some cooperative firms to help them sell what they produced and the government can sell some amount of seeds back to the farmers in a reasonable price. To stabilize the price on the market, they need the government to be involved in buying and selling process. Access to credit is a good way to overcome some of the financial obstacles. For agricultural technology to effectively contribute in raising productivity and poverty reduction, a set of interventions are also needed. These include secure output markets, effective supply systems (including credit), secure and equitable access to land and supporting infrastructure such as roads, telecommunication and irrigation (Dorward *et al.* 2004). In addition, the approach looks at the availability of institutional support required for successive adoption. The multiple source of innovation model encompasses the use of participatory approaches that have evolved from efforts to improve technology development and dissemination. A payment arrangement, either in cash or in kind is one method for solving the problem. Besides, aid organizations working with the government to provide credit facilities to the farmers will help the farmers to sustainably continue using the newly adopted technologies.

7 SPONTANEOUS UPTAKE OF THE TECHNOLOGIES

The best indicator of success is the spontaneous adoption and adaptation by the farmer and the farmer's neighbors, and a continuum of innovations. There has been some spontaneous adoption, mostly from farmers learning the technology from their neighbors. Neighbor in this term implies people living near one another and socially interact and have considerable face to face interaction among one another. Farmers who attended trainings had discussions with other farmers about what they have learnt from the trainings. At the same time there has also been some rejections by farmers who originally participated in the project. Among the farmers who continue to adopt the technologies, the information diffusion usually occurred in coffee shop, at the market place and in a social gathering with individuals or groups through oral transmission. The farmers who adopted the technologies without formal training have got information during informal group meetings or observed the technologies from other farmers and developed interest towards adopting them. This paper measured this particular manner by counting the number of neighbors who took lessons from the trained farmers. The farmers were asked to list all neighbors they shared the technology with. There answer ranged from none to eleven number of neighbors who adopted some of the technologies. Table 33 presents the extent of spontaneous spread to neighbors and the information given to them.

TABLE 33 THE EXTENT OF ECOFARM FARMERS GIVING LESSONS TO NEIGHBORS ON ECOFARM TECHNOLIGES IN THREE DISTRICTS

District	**Samples**	**Proportion in percent**	
		Yes	No
ATJK	32	93.8	6.2
Tach-Armacheho	37	89.2	8.1
Mekhone	33	78.8	15.2

TABLE 34 PERCENT OF FARMERS INTRODUCED TO THE NEW TECHNOLOGIES USING NEW ECO-FARM TECHNOLOGIES WITNESSED BY THE FARMERS PARTICIPATED IN THE PROJECT.

District	Number of samples	Proportion in percent	
		Yes	No
ATJK	32	87.5	12.5
Tach-Armacheho	37	70.3	29.7
Mekhone	33	63.6	36.4

Therefore, this study ought to find out the number of farmers who exchanged seeds, information and ideas to their neighbors. This kind of diffusion happened spontaneously and the effectiveness depends on the kind of technology and the location where it takes place. Accordingly, households who adopted eco-farm technologies in the three districts were 87.5, 70.3, and 63.6 percent in ATJKT, Tach-Armacheho, and Mekhone district respectively (table 34). The extent to which the adoption process progressed mainly depended on the neighbors' interest on seeking ideas and information from their fellow farmers who worked with the project. Therefore, Eco-farming lessons were given to 93.8% of the neighbors in ATJK, 89.2% in Tach-Armacheho, and 78.8% of neighbors in Mekhone districts (Table, 33). The crop exchange activity was facilitated by selling the crop or exchanging it with other crops. Farmers witnessing the actual benefit received by their fellow farmers and most importantly focusing on crops which had the highest level of production were the reason for the spontaneous uptake of the technologies. If there is an intervention at this step, the effectiveness of technology diffusion must be higher. It is difficult for me based on this to assess how many of the neighbor actually adopted technologies.

8 RELATION TO ADOPTION THEORY

Diffusion theory does not lead to the conclusion that one must wait for the diffusion of a new product or practice to reach the poorest people …. In fact, one can accelerate the rate of adoption in any segment of the population through more intensive and more appropriate communication and outreach.

- Lawrence W. Green, Nell H. Gottlieb, and Guy S. Parcel, 1991, p. 114.

Adoption- diffusion theories refer to the process by which an innovation is communicated through certain channels involving the spread of a new idea over time (Rogers, 1983).The adoption process refers to the individual's decision to or not to adopt an innovation. It can be a onetime event or a decision to integrate an innovation in to the farmer's life. Rogers's theory is the foundation for understanding the factors that influence the choices an individual makes to adopt a technology. Rogers' study identified and explained five stages that influence adoption process namely: relative advantage, compatibility, complexity, trialability, and observability. Stage one is when an individual becomes aware of the new technologies. Stage two is when an individual gains enough knowledge about the technologies. Stage three is when an individual decides to adopt or reject the technology. Stage four is when an individual takes action on his or her decision. The fifth stage is when an individual reflects on the decision to continue or discontinue (Rogers, 1995).

Eco-farm project relies heavily on an experimental demonstrations model. Demonstrations of innovations exist for one of two reasons. A demonstration is either an experiment of a promising intervention or a showcase of a proven intervention (Myers, 1978). Being clear about demonstration purpose is important. Eco-farm demonstration was an experimental demonstration run by an extension agent in farmers' own fields and barns to show that experimental results can be reproduced locally. The model of technology transfer was often viewed as the linear model as it assumes a linear relationship between research, extension and farmer with organized source of innovation. The field test carried out for the purpose of assessing the external validity of an intervention with methods by which outcomes were measured. This kind of extension models are usually top-down structures and system which

promote agricultural technologies that had been designed and developed by research scientists with limited inputs from the technology users (farmers).

The important contributions of Rogers model is the idea that the adoption is a process that includes several decision phases, and is not simply a single decision to adopt or not. One way of the model refers to time as a stage through which adopters pass when deciding about adopting new technologies or idea. Rogers 1983 defined the 'innovation-decision as the process through which an individual passes from first knowledge of an innovation, to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation, and to confirmation'.

The innovation diffusion model has several limitations. One of the major shortcomings of the model is it generally assumes that the most important variable is information and the willingness of individuals to change. An individual is characterized according to his or her behavior without considering factors that influence the individual's behavior. In reality many other factors are known to influence the adoption of an agricultural innovation. These include the farmers' objectives, the level of the resource endowments of the individuals, access to resources, availability of support systems and the characteristics of the innovation.

To guide an application on adoption the project need to develop a theory of adoption and of the acquisition of new knowledge. The theory and its empirical application must take culture, farmers' participation, and economic situations seriously and must not rest on ad hoc insights. Farmers complained that the training time given to them is too short to have all the necessary information about the technologies. Farmers in Tigray region particularly said that there was not much professional support from the project to assist the farmers to grasp the whole idea of the adoption process step by step.

The Bridge to Technology.com, 2009 defined technology adoption *as a process that begins with awareness of the technology and progresses through a series of steps that end in appropriate and effective usage*. According to this source, technology adoption consists of five steps:

First, technology adoption requires awareness. At this step the potential users get adequate information about the benefits of the technology. The second step is assessment. At this period, the expected users evaluate the usefulness and usability of the technology and the ease or difficulty of adopting. This is followed by acceptance or refusal of the technology by the users. At this stage, the adopters decide to acquire and use the technology or not. The fourth stage is learning. If they decide to use the technology, the users need to develop the skills and knowledge

required to use the technology effectively. The fifth and the final one is application or usage. In this phase, the users show appropriate and effective use of the technology. According to the farmers in the project areas, all the above steps did not happen as they liked them to happen. When they were waiting for the result in the last year of the project to see how things went with the new technology, the reverse happened and they lost all the harvest. Furthermore, almost all the technologies were introduced at the same time. Farmers do not remember some of the technologies that were introduced. The diffusion of the technologies with all the available problems, lack of water, shortage of land coupled with backward farming practices was not easy to adopt all at once. There were technologies that were totally new for the farmers that need more time and assistance. But no effort was made to get them to have deep knowledge about the individual technology application process. The acceptance level was different from technology to technology. For example young famers are quick learners compared to old ones. Detailed information is needed for the elderly. Women do not have spare time compared to men because they usually are occupied with household works which needed a special consideration. Hence more detailed and focused practice was needed on the individual technologies. It was important for them to know the basic ground components of the technologies in order for them to use the ideas in any given time. However, of all the introduced technologies few of them were remembered and were being applied.

It is widely recognized that innovation comes from multiple sources and different stakeholders represented and affects the appropriateness of the new technologies (Sulaiman *et al*, 2006). As in many countries combining participatory technology development with Roger's diffusion theory should be the appropriate model to use. Technological change has been the basis for increasing agricultural productivity and promoting agricultural development. Participatory methodologies are often characterized as being reflexive, flexible and interactive, in contrast with the rigid linear central source model. No one has deeper knowledge about the problem than the farmers themselves. Farmers participation was not sufficiently considered in the decision making process. Farmers respond that when the project aimed to introduce the technologies, they were not consulted. Ideally, there should be a greater sense of ownership throughout the technology diffusion. However upstream and downstream sectors influence the adoption of technologies by farmers, they can also learn from farmers so that technologies introduced take into account the effects on the farmers participation.

Although the concept of participatory innovation development is fascinating, the methods, tools and operational guidelines are not adequately developed in a sense that it could accommodate

the interests and perspectives of farmers with different background. This is typically characterized as a top-down process, whereby researchers develop the innovation, extension workers promote its use, and farmers either adopt or reject the innovation based on the features important to them. However, participation redefines the role of farmers from being simply recipients to actors, who influence and provide inputs to the process. The needs of the users, who include women as well as men in farming households, are taken into account. Involving farmers duly identify and sort out the purpose of the project is important in ensuring the participation of the farmers in the choice and priority of the technology in terms of its long and short run benefits and the capacity and the social acceptance of the technologies. Most importantly the approach does not have a particular tool to narrow the gap between the creative thoughts and findings of innovative farmers.

The proposal submitted for the funding and the actual work do not usually match. The reports written at the end of the project are perfect and objective is achieved. What happens in many cases, however, is that the would-be beneficiaries, i.e the farmers are not consulted or included in the decision-making process and thus, the actual problems of the farmers are set aside. The farmers complain that the project came with a set of technologies and they were not consulted. They are only made to participate in the training. In most of the adoption processes, the farmers grasp the released technologies as the project wanted them to do. Three days training were not enough to help farmers to acquire the required knowledge and information to adopt the technologies. It was a practical training that they were needed instead of oral information given by the project workers. The project did not consider differences of skill reception capability and educational background of the technology beneficiaries. Some technologies were simply too costly for the farmers. For instance the high cost of maintenance to fix the rice dehuller machine and the unavailability of the spare parts around the area reduced the functionality of the technology. The introduction of this machine did not consider the economic aspect of the farmers.

9 CONCLUSION

Farmers in developing countries are the victims of climate change. Therefore, protecting agriculture from climate change must be the main issue. Efficient agricultural machineries, agricultural chemicals and fertilizers, genetic improvements in crops and changes in farm management techniques have been used to change and transform different developed countries' agriculture. The introduction of those improved agricultural technologies to developing countries should be economically sound, environmentally protective and socially acceptable. The preservation of environment and the life of human beings would be better ensured if more of the farmers made the transition from traditional way of farming to a sustainable one.

The introduction of improved agricultural technologies to the three dry land areas in Ethiopia has helped in increasing production and productivity of food crops, increasing diary production and productivity through improved dry land resistant crops, crop and soil management activities and established drought cropping farming systems. The awareness coupled with the simplicity of the technology helped farmers to progress in the adoption process. As I have heard from the farmers' themselves, remarkable achievements have been registered as a result of the implementation of the project. Interestingly, it has not only improved the lives of participating members, but their activities have had spillover effects on the lives of those who are not members of the project. Consequently, the lives of many farmers have been significantly changing since the implementation of the project in the areas where the project was implemented. The effort of the eco-farm project to introduce new agricultural technologies is highly commendable. Even though it encountered some problems, the legacy that the eco-farm project left behind in the three regions of Ethiopia is changing the lives and attitudes of the people.

The farmers have benefited a lot in adopting some of the technologies to their and their environment's benefit. Among the respondent farmers, around 83.8, 30.3, and 10 percent of the farmers in ATJK, Mekhone and Tach-Armacheho districts respectively were adopters of more than four introduced technologies. 84.4% of ATJK farmers (which is the highest) adopted the maize varieties and 59.4% adopted the new varieties of Haricot bean (Table 10). In Tach-Armacheho district; new rice, finger millet and ground nut varieties were adopted at 67.6%, 48.6% and 37.8% respectively (Table 11). The adoption rates in Mekhone district were not

promising. According to the data collected, of all the adopted technologies, dairy goat production was the highest in percentage with 27.3% (Table 12).

Factors that trigger adoption of new technologies comprise of progressive, young and educated farmers motivated by the increased productivity of crops. As a result, 84.4, 89.2, and 69.7 percent of farmers in ATJK, Tach-Armacheho and Mekhone respectively said increased productivity of crops was the main reason to adopt the introduced crops. The major constraints mentioned against adopting eco-farm technologies were the very low rain fall, high cost of input materials (fertilizers) and labor. Factors that were important in their adoption decision was lack of persistent rainfall, lack of education and lack of motivation to take risk. Risk perception is an endogenous factor and thus the implication of risk in terms of farmer decisions may change if the perceptions of farmers change (*Feder and O'Mara 1982*). Perceptions of risk related to new technology diminish over time through the acquisition of experience and information (*Feder and Umali 1993*).

However, not all farmers adopted the technologies introduced because they were new to them. They hesitated to apply new technologies because they did not believe that new technologies can ensure high yield. These farmers are usually old and work based on their own experience. Though, farmers perceived technology as good thing to them; they still faced problems in the introduction of new agricultural technologies and their adoption by the smallholders will benefit the farmers and simultaneously protect the environment. Agriculture technologies that can enable the farmers to produce crops and livestock without damaging the ecosystem are important.

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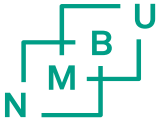

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