CHAPTER II

LITERATURE REVIEW

This chapter provides a review of literature on technology adoption and role of organic matters for soil maintenance and improvement because this study aims to analyze the factors affecting adoption on soil conservation measures using organic materials. Among the factors that contribute to the growth in agricultural productivity; technology is the most important. Firstly, the chapter gives a review of the studies on the beneficial effects of organic materials to conserve and improve the soil and the limitation and challenges of organic materials. Secondly, a brief introduction of the adoption term is defined and the importance and process of technology adoption is also reviewed. Finally, the factors affecting the general process of adoption and farmers' knowledge on adoption and soil are reviewed in this chapter.

2.1 Role of organic materials for soil maintenance and improvement

Healthy soil is the foundation of the food system. It produces healthy crops that in turn nourish people. Plants obtain nutrients from two natural sources organic matter and minerals. Organic matter includes any plant or animal material that returns to the soil and goes through the decomposition process. The effects of organic matter on soil are multi-dimensional and involve physical as well as chemical and biological properties of soils. Organic matter can improve soil physical properties, such as structure, texture, water storage, aggregation, soil stability, and prevention of soil hardening. Organic matter also improves soil chemical properties such as retention of cations in soil, release of inorganic nutrients, and prevention of phosphorous fixation. Therefore, organic matter is very important for improving soil properties (Guthrie, 1940).

For most farmers, the only possible way to increase the organic matter in their soils is through an increase in total organic matter production by means of good crop management, since better crops mean more total dry matter produced per unit area by the aboveground plant parts and the roots. After plants mature and die, they decompose (break down) into soil organic matter (Violic, 2000). Hills *et al.* (1908) and Gale and Cambardella (2000) also stated that organic matter, as residue on the soil surface or as a binding agent for aggregates near the surface, played an important role in decreasing soil erosion. Surface residues intercepted raindrops and decreased their potential to detach soil particles. These surface residues also slowed water as it flowed across the field, giving it a better chance to infiltrate into the soil. Aggregates and large channels greatly enhanced the ability of soil to conduct water from the surface into the subsoil. As a physical buffer, crop residues protected soil from the direct impacts of rain, wind and sunlight leading to improved soil structure, reduced soil temperature and evaporation, increased infiltration, and reduced runoff and erosion.

Hulugalle *et al*. (1986) stated that application of plant residues to soil was known to have beneficial effects on soil nutrients, soil physical conditions, soil biological activity and crop performance. Fairhurst *et al.* (2007) also indicated that incorporation of stubble and straw into the soil returned most of the nutrients taken up by the crop, and helped to conserve soil nutrient reserves in the long term.

Palm *et al*. (1997) stated that organic inputs in the forms of green manuring or otherwise could increase the total amount of nutrients added, and also influence availability of nutrients. Simarly, Pung *et al*. (2004) also stated that the use of green manures in between successive crops helped maintain or increase organic matter in soils. They also overlooked other benefits from green manures that could produce longer lasting effects. This study showed that high plant biomass and deep tap root system, which reduced soil crusting, improved infiltration, increased organic matter and reduced subsoil compaction. These soil improvements contributed to disease management and crop health. FADINAP (2000) also found that many green manure legumes such as fast-growing, short-duration and stem-nodulation sesbania (*Sesbania rostrata*) could accumulate N rapidly. Green manure decomposed rapidly when incorporated into the soil and might provide a substitute for fertilizer N applications, especially during vegetative growth.

Khan *et al*. (2010) proved that farm yard manure carried its impact on soil physical properties and health. Farm yard manure had positive role in maintaining physical properties of soil as it took time to decompose completely. Farm yard manure significantly increased saturated hydraulic conductivity in deep tillage method and reduced bulk density of soil. The farm yard manure also affected the physical properties as it increased hydraulic conductivity.

Hussain *et al*. (2001) stated that use of compost could be beneficial to improve organic matter status. Compost was rich source of nutrients with high organic matter content. Physical and chemical properties of soil could be improved by using compost, which might ultimately increase crop yields. So use of compost was the need of the time.

Carucci (2001) stated that the level of soil organic matter could be restored or maintained through the application of green manure, compost and farmyard manure. These could release nutrient earlier than the other organic materials that were more resistant to decomposition. Moreover, he stated that organic matter could absorb considerable amount of water, often 5 to 6 times of its own weight. Soil fertility problems remained a high priority for agricultural development in the central Dry Zone of Myanmar and the role of scientific information was important to improve this situation. Gupta (1999) also indicated that to overcome the soil fertility problem, farmers should use mainly chemical fertilizer and organic manure for crop production improvement. Although soluble inorganic fertilizer gave rapid results in term of correcting immediate deficiency of nutrients from the environmental view point, their use was becoming less desirable. The increasing cost of inorganic fertilizer and their adverse effects on soil productivity, farmers were being encouraged to increase use of available organic waste and crop residues as organic or biofertilizer. However, there are some limitations in using organic materials for soil conservation in the Dry Zone area.

2.2 Limitation and challenges to organic matters application

Having so many advantages in using organic fertilizers, some limitations also can be found such as; difficulties to apply as it can be bulky with high handling and transportation casts, low availability, has to be applied at the beginning of the crop, can have unpleasant odor making it undesirable for farmers and for the others, may have high costs per unit of nutrients and sometimes more expensive than inorganic fertilizers. Time gap between two crops may also limit the use of organic fertilizers. Mostly they require land, labour and other inputs for their production and application. As a result of that, the use of organic fertilizers such as compost that require high labour intensity will be limited in labour scare societies (Pandey, 1999).

There is also a limited storage and retail marketing facilities for organic manures. Therefore, it is not easily accessible for most of farmers. Even though the market for chemical fertilizers is controlled as a standard product, selling of organic manure is done without any standards. Beliefs of farmers may also affect adversely to the application of organic fertilizers. Some believe that organic manures may carry pests, pathogens and weed seeds and propagate them in the current or following crops. However, increase use of chemical fertilizer is considered to be environment pollutants. Therefore, integrated soil nutrient management requires greater management skills than those required for the application of inorganic fertilizers alone or organic fertilizer alone; since it requires combination of two inputs in correct proportions. Precision in the depth of application is based on specific factors such as soil or plant tests and additional time investment to learn, acquire and use of such knowledge-intensive technologies (Fairhurst *et al*., 2007).

Therefore, introduction of technologies is not enough for better performance; encouragement of farmers to adopt those technologies also is a must.

2.3 Defining adoption

Rogers (1962) defines the adoption process is the mental process an individual passes from first hearing about an innovation to the final adoption. A quantitative definition which distinguishes the individual (farm level) adoption and aggregate adoption was given by Schultz (1975). Final adoption at the level of the individual farmer is defined as the degree of use of new technology and it's potential. Technology results in the improvement of the socio economic conditions of the society. It is in the diffusion stage that new technologies produce impact on the economy (Feder *et al*., 1985).

2.4 Adoption process

Adoption is a process of an individual mind. Adoption of an innovation means the process by which a particular farmer is exposed, considered and finally rejects or practices a particular innovation. The degree of adoption in an individual is related to his social status based on his income, education, and occupation. All individuals in a social system do not adopt an innovation at the same time. They adopt an innovation in an ordered time sequence with the time dimension involved in the adoption process.

Mosher (1978) indicated that the process of the adoption of innovations composed of five successive steps: (1) awareness, (2) interest, (3) evaluation, (4) first trial, and (5) either repeated use or rejection.

1. Awareness: The first step towards adoption of an innovation, obviously, is to become aware that it exists.

2. Interest: The second step is to become personally interested.

3. Evaluation: Once a farmer has become interested in an innovation, he begins the process of evaluation it, and of deciding whether or not he wishes to try it.

4. First trial: The fourth step is actual trial on the farm.

5. Either repeated use or rejection: Not until a farmer begins to use an innovation, the second, third, fourth time can be said to have "adopted" it. Only repeated use indicated that the adoption has taken place.

2.5 Factors affecting on the adoption of technologies

Technology adoption process is expected to be affected by several factors. There is a wide body of literature regarding the determinants of adoption of technical innovations in agriculture. A number of adoption studies report that technology adoption is linked to farmer resource endowment in terms of human, physical and financial capital, risk preferences, location factors and characteristics of technology itself (Simtowe, 2006). Featherstone and Goodwin (1993) stated that most of the socio-economic empirical studies on adoption of soil conservation focused on the following categories of variables that influenced a farmer's decision to adopt; farm / physical factors such as social status, attitudes, beliefs towards land degradation and soil conservation and institutional factors like extension services and participation in soil conservation programmes; economic / financial factors such as farm income, indebtedness, investment costs, availability of labour and risk.

In another study, Mendis (2005) studied the factors affecting adoption of recommended crop management practices in paddy cultivation in Kulutara District, Sri Lanka. The study revealed that adoption of soil fertility improvement and sustenance practice was significantly related to education, land, income, credit, sources of information, extension activities and visit, and membership in farmers' organization; and adoption of fertilizer management practices were significantly related to education, land tenure, income, source of information, extension activities and visits and membership in a farmers' organization. Masavisuthi (2005) studied that the socio-economic factors were significantly correlated with adoption of sunflower production technology including education, secondary income of farmers and income. Therefore, characteristics of the household head and the household, economic factors and institutional contribution towards the technology are considered as more important factors that influence the adoption process.

Ryan and Gross (1943) were the first to show that technological adoption varies from farmer to farmer. Farmer attributes that were commonly included in adoption studies were education, age and erosion perception. Simtowe (2006) found a negative influence of age on technology adoption in their studies; implying that older farmers had a tendency to stick to their old production technologies and they were usually unwilling to accept change. In addition, young people were associated with higher risk taking behavior than the elderly. However, Damisa and Igonoh (2007) argued that older farmers were more likely to try new technologies as they were rich with more resources than younger farmers. Yamota and Tan-Cruz (2007) gave evidence to the importance of age on technology adoption. Zhou *et al*. (2008) found a complex impact of education on technology adoption in their study. They indicated farmers' membership in an extension service, as the most important driving factor for the adoption technology in China. Ayele (1999) also showed that high school education were significant determinants of the decision (participation) and use intensity (consumption).

Damisa and Igonoh (2007) stated that farm size, family size and family income were considered as important household characteristics that significantly affected the technology adoption process. Ervin and Ervin (1982) showed that farm experience best explained the adoption of environmental practices, while variables relating to the size of farm operation best explained the adoption of commercial practices. Zhou *et al*. (2008) observed the same result that farm size had a significant positive effect on technology adoption. Shultz *et al*. (1997) found that land tenure contributed to adoption, since landowners tended to adopt more frequently than tenants, an argument that justified numerous efforts to reduce tenure insecurity. Sarwar *et al*. (2007) confirmed that with increased landholding farmers had better choices to experiment with new technologies as compared to resource poor farmers. Zhou *et al*. (2008) also observed that households with large farms were having higher adoption possibilities than small farms. Some recent studies had looked at the specific aspects of the influence of family size on technology adoption. Namara *et al*. (2003) found that a significant positive influence of family size on technology adoption in their studies. IFAD (2003) found the same results that households with more availability of family labour would find it easier to face the higher demand for labour associated with organic methods of production. Similarly, Ayele (1999) showed that the family members above the age of 15 were having the highest impact on the probability of adoption decision. He also showed that the number of livestock owned, credit and fertilizer use were significant determinants of the decision (participation) and use intensity (consumption).

Oluoch-Kosura *et al*. (2001) stated that socio-economic factors generally influence farmers' adoption of intensification technologies. These included farmer-specific factors, resource or technology-specific characteristics and institutional factors. Karki and Bauer (2004) stated that farmers' decision depended on their needs; cost, incurred and benefit accruing to it would be the major motivating factors for the acceptance or rejection of a particular technology. Training and extension contacts could be considered as major institutional factors that affect technology adoption.

According to Palis (2006), technology adoption in agriculture has often been problematic. Although various agricultural technologies have been developed over the past half-century, many can be found only in scientific journals and are not being practiced by their target users-farmers. Therefore, extension program has to develop technology packages that address farmers' resources constrains rather than wholesale recommendations on fertilizer and other new technology options (Wubeneh and Sanders, 2006). Therefore, extension activities are important for adoption new technologies. Because an effective extension agent will also help not only to change and increase the rates of adoption of new (appropriate) technologies, but also to reinforce those current practices of the land user that are beneficial. The extension agent should help the land user abandon an appropriate ways and technologies which will hinder the land user's progress (Guerin, 2000). Bonati and Gelb (2005) also stated that agricultural extension by its nature had an important role in promoting the adoption of new technologies and innovations. Extension organizations had a key role in brokering between providers of technologies and farmers. Nkamleu (2007) indicated that contacts with extension was found to be positively and significantly related to farmers' adoption in integrated soil nutrient management.

For soil conservation adoption technologies, Carlson *et al.* (1977) also found that increasing level of education, farm size, and perception of soil erosion, double cropping, and increasing net farm income were moderately associated with the application of soil conservation adoption practices could be successfully predicted the application of soil conservation of Australian farmers. Rahm and Huffman (1984) stated that other factors commonly found in the literature to be related with the adoption of soil conservation practices were the level of non-farming income, labor and / or machinery availability, land tenancy issues (property incentives adoption and investment), continuity of sons / relatives in farming, and the existence of public support programmes. Lastly, lower income farmers were usually more concerned with short term survival than with the long term benefits of soil conservation.

Hoover and Witala (1980) found that age was an important factor in their study of Nebraska farmers. Their results indicated that the younger and more educated farmers were more likely to perceive erosion as a problem and therefore perceive benefits from using conservation practices. Reardon *et al.* (1995) stated that conservation decisions were also closely linked with crop diversification. Empirical studies had shown that farmers usually allocate the bulk of production and conservation technologies to cash crops, either because the profitability was higher than for subsistence crops, or because there was credit or input provision in cash crop schemes. Moreover, Clay *et al*. (1995) stated that some crop mixes (such as a high share of perennials) or land use patterns (such as a high share of pasture and fallow) were substitutes for conservation investments.

Farmers' responses to soil erosion will depend on many diverging factors, both technical (cropping patterns, slope, type of soil, etc.) and socio-economic (age, skill, wealth, etc.). One option is to do nothing, maintain the same technology, practices and level of input use, which leads to a continued soil loss and a decline in agricultural production. A second option is to intensify production substituting other inputs (such as fertilizers) for topsoil depth, which generally worsen soil loss and increases production costs. A third option is to adopt new practices to conserve soil, which may have a negative economic effect on the short run but a positive overall economic effect in the long run, although ambiguous evidence exists in this sense. The last option is to regenerate topsoil, which incurs even larger costs (Calatrava *et al*., 2007).

Winters *et al*. (2002) also found that parcel slope, as an indicator of erosion potential, was a farm attribute frequently studied. Slope also positively affected conservation investments in Saharan Africa. Damisa and Igonoh (2007) also stated that factors constraining the adoption of technologies that enhanced soil fertility included that the traditional practice of shifting cultivation, unavailability of fertilizer responsive varieties, lack of credit, unfavorable price relationships and deficiencies in the procurement and delivery systems.

2.6 Farmers' knowledge on adoption technologies and soil

Many development projects and policies have collapsed because of a failure to understand local knowledge and how these influences the way farmers manage natural resources (Schoonmaker-Freudenberger, 1994). Some researchers have found that use of indigenous knowledge facilitates soil survey and land evaluation for agricultural development and increases the probability that resulting projects will meet community needs and respect cultural values (Barrios and Trejo, 2003). Also, Nyeko *et al.* (2002) proved that there had been a general failure of programmes to address situations where farmers' knowledge was lacking and inadequate. Osbahra and Allan (2003) also stated that local knowledge was employed in an array of methods to manage soil fertility depending on labour and capital. Accurate knowledge about an innovation had been identified as the necessary condition for adoption (Yapa and Mayfield, 1978).

Rahman (2003) indicated that sustainability of agricultural production was largely dependent on the action of farmers and their decision making abilities given the level of knowledge and information that was available to them. Similarly, Brouwers (1993) and Sandor & Furbee (1996) stated that farmers' soil knowledge offered a different set of temporal and spatial scales with regard to land use, which had important implications for sustainable agriculture. Deugd *et al.* (1998) also indicated that improving farmers' knowledge and their capacity to observe and experiment was an essential element in the development of ISFM technologies.

Masavisuthi (2005) studied the farmer's adoption of sunflower technology under extension and development project. This research revealed a moderate of knowledge about the sunflower production among the farmers and their adoption of sunflower production technology was at the low level. The knowledge about sunflower technology factors were significantly correlated with the adoption of sunflower technology. On the other hand, the more knowledge the farmers had, the higher level of adoption in sunflower production technology.

There are many constraints in using soil fertility improvement and soil conservation technologies. Osbahra and Allan (2003) indicated that some extent knowledge, the scarcity of inputs, labour, land and capital could only be overcome by intervention at the policy level in order to adopt soil fertility improvement technologies. Birmingham (2003) and Gray and Morant (2003) also stated that there was good correlation between farmers' knowledge of soils and the soil chemical and physical properties (except stoniness) as others found. Sa'idou *et al.* (2004) indicated that farmers' access to the extension service (providing information and knowledge) might also improve soil fertility management. Knowledge was generated through building on farmers' experiences and through learning by doing. Osbahra (1997) stated that farmers relied on their local knowledge of soil characteristics and plant indicators to focus effort in 'precision farming' methods, in which they targeted their planting strategies and additions of nutrients to specific places and soil types, with the aim of maximizing nutrient recycling.

Therefore, a good understanding of farmers' knowledge needs to study in order to ensure a sustainable adoption of soil conservation technologies. This would be instrumental in bridging the current social and psychological knowledge gap on adoption of soil conservation practices using organic materials. It will also form the basis for understanding the psychological and social factors underlying the adoption.

2.7 Model for adoption behavior

Quite a large number of the studies have investigated the influence of various socio-economic, cultural and political factors on willingness of farmers to use new technologies (Adesina and Zinnah, 1993). In many of the studies on adoption behavior, the dependent variable was constrained to lie between 0 and 1 and the models used were exponential functions while univariate and multivariate logit and probit models including their modified forms have been used extensively to study the adoption behavior of farmers and consumers.

Shekya and Flinn (1985) have recommended probit model for functional forms with limited dependent variables that are continuous between 0 and 1 and logit models for discrete dependent variables. The logit model, which is based on cumulative logistic probability functions, is computational easier to use than other types of model and it also has the advantage to predict the probability of farmers adopting the any technology.

Variants of the logit model includes the ordinary logit (binary logit), the ordinal logistic, nominal logistic and multinomial logit. Binary logistic models are the most popular type because binary data are a common type of categorical data- the response is either a “success” or a “failure”. The ordinal logistic regression model is used when the dependent variable is ordered; while nominal logistic handles nominal categorical responses. Multinomial logistic modeling is a special case of ordinary logistic approach, developed to address the case where the dependent variable can take on more than two values that are not ordered.

The binary logit regression is a type of regression where the dependent variable is converted into a dichotomous binary variable coded 0 and 1. Therefore, this model is considered appropriate in such a situation. It requires far fewer assumptions than the other two mentioned above (Homser and Lemeshow, 1989). It is also called logit, which is applicable to a broader range of research situations and is able to predict the presence or absence of a characteristic or outcome based on values of a set of predictor variables.

Many past studies have demonstrated that logit model can be applied to capture the influence of socioeconomic variables on farmers' adoption decision (Zhou *et al.,* 2008). In this model farmers are assumed to make adoption decision based upon an objective of utility maximization. It is similar to a non-linear regression model but is suited to models where the dependent variable is dichotomous. There is flexibility in the model where independent variables can be interval level or categorical; they should be dummy or indicators.