CHAPTER II

LITERATURE REVIEW

This chapter will review some literature dealing with the adoption of chemical fertilizer technology and socio-economic factors that affect chemical fertilizer adoption. Attempts will be made the research methods dealing with adoption studies, specifically the use of logit and multinomial logit model to determine the adoption.

2.1 Technology adoption

Technology adoption process is a mental process through which an individual passes from first hearing about an innovation to final adoption. This process is conceptualized in five stages or steps: awareness, interest, evaluation, trial and adoption. At awareness stage the individual is exposed to the innovation but lacks complete information about it. He then becomes interested in the innovation and seeks information about it at the interest stage. At the evaluation stage the individual mentally applies the innovation to his present and anticipated future situations, and then decides whether or not to try it. The individual uses the innovation on a small scale in order to determine its utility in his own situation at the trial stage. At the adoption stage the individual decides to continue the full use of the innovation (Rogers, 1962). According to the economic constraints model (Aikens *et al*., 1975), resource endowments are the major determinants of observed adoption behavior, where lack of the access to capital and inadequate farm size can significantly impede adoption decisions. The more technically complex the innovation, may be the less attractive it to many farmers. The decision of whether or not to adopt a new technology will be based on a careful evaluation of a large number of technical, economical and social factors associated with the technology. The economic potential of a new technology in terms of yields, costs of production and profit are also very important factors for adoption decision. However, typically the economic impact of an innovation is not known in advance with certainty. Unfamiliarity with the new technology makes the initial impact on yields and input usage uncertain.

The major constraint of agricultural development is the lack of suitable technologies (Joshi *et al.*, 2002); and the success of any agricultural production program depends largely on the application of appropriate technology that will sustain the production. The development of an agricultural technology may include suitable crops, crop varieties, correct crop management practices and adequate level of inputs (Myint, 2001). Farmers have difficulties on the adoption of modern agricultural technologies and the use of modern inputs due to the availability of input, availability of credit, farmer's perception of the benefit of new technology and limited knowledge of modern inputs (Nerlove *et al.*, 1994).

The definition of adoption refers to the degree of use of a new technology as a quantitative measure of the extent of adoption. In most cases, agricultural technologies are introduced in packages that include several components of high yielding varieties (HYV), fertilizers and corresponding land preparation practices. While the components of the package may complement each other, some of them can be adopted independently.

Byerlee and Polanco (1986) demonstrated that farmers adopt improved technological components in a stepwise manner.

2.1.1 Role of chemical fertilizers

In 1976, Myanmar government encouraged the implementation of production programs that combined the use of high yielding varieties and increased application of chemical fertilizers. However; in the long term, the high yields will not be sustained unless there is an adequate provision of supply of fertilizers including appropriate amounts and types. As high yielding plant varieties take up a large amount of nutrients from the soil, the inability to replenish the lost nutrients will cause severe nutrient depletion and the corresponding decline in crop production (S. Htay Win, http://www.fao.org/docrep / 010/ag120e/AG120E23.htm).

As much as 75 percent of crop yield increases since the mid-1960s are directly or indirectly attributable to fertilizer use (Viyas 1983, cited in Reardon and Barrett 1999; Bumb 1995). For example, in India fifty percent of the increase in grain production is attributable to inorganic fertilizer (Hopper 1993, cited in Bumb 1995). The low use of chemical fertilizer is a major worry from both the environmental and food production perspectives (Reardon and Barrett, 1999). In higher potential areas, some fertilizer use on maize is often economically profitable even at higher relative prices of fertilizer (Heisey and Mwangi 1996). As a result of declining real prices over much of the past century, fertilizer has been vital to the rapid increases in world crop production (Tomich, *et al*., 1995). Fertilizers also complement other major inputs and practices (e.g., improved seeds, better water control) that have had the greatest impact on yield. For the foreseeable future, "the environmental consequences of continued low use of fertilizers" through nutrient mining and increased use of marginal lands "are more inevitable and devastating than those anticipated from increased fertilizer use" (Dudal and Byrnes 1993, Matlon and Spencer, 1984).

Maize has a strong exhausting effect on the soil, and it is generally observed that maize fails to produce good grain yield in plots without fertilizer application (Kumar, 1993). In most experiments, maize response to nitrogen (N) is very significant. Under continuous cropping, fertilizer N is the most important nutrient for maize production. Nitrogen and Phosphorous (P) deficits are a severe and widespread biophysical constraint to smallholder maize productivity, and in turn to the long-term food security of the resource poor in southern and eastern Africa (Sanchez *et al*., 1997). Even when fertilizer is applied on farmers' fields, it is often used inefficiently (measured by the grain yield response to the addition of chemical N and P fertilizers), which reduces its overall profitability (Kumwenda *et al.*, 1996).

In Myanmar, the farmers used to apply Urea and do not apply P and K fertilizer in long term, imbalance nutrients occurred and damaged the natural balance of social and environment (S. Htay Win, http://www.fao.org/docrep / 010/ag120e /AG 1 20E23.htm). Fertilizer has been a major component of improved maize production technologies, because maize is a heavy nutrient feeder; hence, it withdraws heavy dose of nutrients from soil for plant growth. The recommended fertilizer rate for hilly region is N 100 kilogram per hectare (kg ha^{-1}), P_2O_5 250 kg ha^{-1} and Potassium (K) 100 kg ha^{-1} with cattle manure of 10 card-load ha^{-1} (2500 kg ha^{-1}) for maize production (DAR, 2005).

At the low levels of soil nutrients, it has been noted that inorganic fertilizer is highly needed to reverse the declining soil fertility (Palm *et al*., 1997; Sanders and Ahmed, 2001). Everywhere else in the world where crop yields have been substantially increased, inorganic fertilizer has been noted as a basic component, often complemented with other soil fertility improving techniques (Sanders and Ahmed, 2001). A moderate addition of N fertilizer tends to increase net returns and reduce the risk from year-to-year variability in weather and prices (Singh *et al*., 2001). Most improved varieties are responsive to fertilizer and economic yields are usually obtained after fertilizer application. But use of fertilizer is constrained by high prices and farmers' lack of knowledge (Kaliba *et al*., 1998).

Soil problem in high rainfall areas such as mountainous regions in Myanmar, P is fixed and unavailable for plant use and Aluminium (Al), Manganese (Mn) and Iron (Fe) could have reached toxic levels for some plants (S. Htay Win, http://www.fao.org/docrep / 010/ag120e/AG120E23.htm). Acidic soils are characterized by low pH; deficiencies of P, calcium (Ca), and magnesium (Mg), and toxic levels of Al. Acid infertility factors limit crop growth and yield as well as soil productivity in highly weathered soils of humid and sub-humid regions of the world due to the deficiencies of essential nutrient elements (Akinrinde *et al.*, 2005). According to Akinrinde and Okeleye (2005), crops have become so expensive to produce when nutrient deficiencies are not toc be allowed to limit their yields.

2.1.2 Role of the liming process

Liming is an ancient agricultural practice for rehabilitating acid soils. The overall effects of lime on soils include increased soil pH, Ca and Mg saturation, neutralization of toxic concentrations of Al, increase in pH dependent CEC resulting in absorption and hydrolysis of Ca2+ (Mg2+), increase in P availability and improved nutrient uptake by plants (Nicholaides *et al.*, 1983; Oguntoyinbo *et al.,* 1996). Wambeke (1992) reported the inefficiency in liming alone to obtain plant response in nutrient deficient soils. In a liming experiment, Morrison *et al.,* (1989) reported double control yield of 1000 kg ha^{-1} maize for soils with high organic matter and lime while plots with fertilizer plus lime treatment, had 3-4 times yield of lime plus organic matter plots. Friensen *et al*., (1982) found that lime applications at low rates were required to sustain yield. Lime application as powdered Ca $(OH)_2$ at the rate of 0.5 tons ha^{-1} was reported to maintain nearly the maximum maize yield for two years after lime application; while lime applied at the rate of 2 t ha^{-1} Ca $(OH)_2$ could sustain yield for over five years. Leaching loses of Ca in lime treated plots after 3 years of lime application were attributed to the presence of acidifying N fertilizer; as most of the Ca migrated with Nitrate (NO_3^-) and Chloride (Cl^-) anions, but no pH change was reported (Wambeke, 1992). For several crops, liming results in some chemical changes in the soil such as, increase in pH effective cation exchange capacity (ECEC), and exchangeable Ca, decrease in toxic elements for example Al^{3+} and Mn^{2+} and changes in the proportion of basic cations in CEC sites. Available results on the effect of liming on soil physical attributes are controversial.

Low soil fertility has been recognized as one of the major biophysical constraints affecting agriculture in Southern Shan State. Soil fertility depletion in smallholder farm is a fundamental biophysical cause of declining per capita food production. This depletion is mainly due to intensive and continuous cropping with low application of fertilizer; causing a negative balance between nutrient supply extractions (Sanchez *et al.,* 1997). Lime application at the rate of 300-550 kg ha^{-1} is needed to improve the fertility in acid soils in this region (DAR, 2003).

2.1.3 Role of extension in technology adoption

Personal communications involve a direct face-to-face exchange between the communicator and communicatee. Cosmopolite information sources are most important at the awareness stage, and localize information sources are most important at the evaluation stage (Rogers, 1962). So extension authorities have a higher responsibility in the technology adoption process. 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' resource constraints rather than wholesale recommendations on fertilizer dosages and other new technology options (Wubeneh and Sanders, 2006). If government encourages farmers to participate in extension services and provide them with opportunity to get the experience of technology, then the technology could be adopted by farmers (Wang *et al*., 2007).

The technology adoption aims to increase production not only for national food security but also for exporting.

2.2 Factors affecting technology adoption

Factors constraining the adoption of technologies that enhance soil fertility include: 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 (Damisa and Igonoh, 2007). Profitability was found to be a necessary but not a sufficient condition for fertilizer adoption. Although Lindner *et al.,* (1987) reported profitability as the single most important factor for explaining technology adoption; Oluoch- Kosura *et al*., (2001) and Asrat *et al*., (2004) argued that socio-economic factors generally influence farmers' adoption of intensification technologies. These include farmer-specific factors, resource or technology-specific characteristics and institutional factors. Within this frame condition, farmers' decision depends 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 (Karki, 2004).

Yamota and Tan-Cruz (2007) gives evidence to the importance of age on technology adoption. Islam et al*.,* (2007) and Simtowe (2006) have found a negative influence of age on technology adoption in their studies; implying that older farmers have a tendency to stick to their old production techniques and they are usually unwilling to accept change. In addition, young people are associated with higher risk taking behavior than the elderly. But Damisa and Igonoh (2007) have argued that older farmers are more likely to try new technologies as they are rich with more resources than younger farmers. Farm size, family size and family income can be considered as important household characteristics that significantly affect to the technology adoption process. Zhou *et al*., (2008) have identified farm size having a significant positive effect on technology adoption and were able to find that households with large farms having higher adoption possibilities than small farms. Same results were observed by Sarwar *et al.,* (2007), confirming that with increased landholding, farmers have better choices to experiment with new technologies as compared to resource poor farmers. Contacts with extension was found to be positively and significantly related to farmers' adoption in integrated soil nutrient management (Nkamleu, 2007), and also to the adoption of improved maize varieties (Ransom *et al.*, 2003).

The land: labour ratio is particularly important because of the need to test the assumption that as land pressure increases, farmers are likely to intensify their soil management efforts so as to improve productivity. Natural causes such as moisture stress due to drought also result in low responses to inputs, which further depress the relative profitability of soil fertility inputs (Hardwick *et al*., 2004).

Shields *et al.,* (1993) suggested that farmers' ability to mobilize sufficient labor, the availability of capital, farm size and risk aversion were the significant factors that influence on maize farmers' decisions to adopt new technology. The lack of cash would reduce the use of hybrid seeds, basal and top dressing fertilizers. Certainty in the expected rainfall, associated with higher anticipated output levels would encourage farmers to adopt new technologies.

Smale *et al*., (1995) suggested that farmers' perceptions of relative yield variance affect the area planted and the fertilizer application to hybrid maize. Adunga (1997) analyzed the factors influencing fertilizer adoption and the intensity of its use among individual farm household in Lume district of Ethiopia. The results of the econometric analysis showed that farm households having a positive reaction to fertilizer use. Extension service was the strongest force behind the decision of farm households to adopt inorganic fertilizer. The number of oxen per household used as a proxy for its wealth, and hired labor were also important factors that positively influenced on fertilizer adoption decision. The analysis of the determinants of the intensity of fertilizer use revealed that the wealth of farm households, access to credit, the use of hired labor and fertilizer-crop price ratio had significant positive effects on it.

An assessment of the adoption of seed and fertilizer packages and the role of credit in smallholder maize production in Kenya was examined by Salasya *et al*., in 1998. Cattle ownership, land-labor ratio, maize cultivation experience and the farmers' location were significant factors influencing on the adoption of fertilizer. Making credit available to farmers is an important way of increasing the adoption of improved maize technologies and improving the level of production.

Moreover, Degu *et al*., (2000) assessed the adoption of improved maize seed and fertilizer packages in Ethiopia. Factors affecting the adoption of improved maize showed that number of total livestock units (TLU), agro-ecological zone, extension services, use of credit and membership of an organization all significantly influenced on the probability of adoption.

Ayele (1999) showed that the number of livestock owned, credit and family members above the age of 15 having the highest impact on the probability of adoption decision. Credit, fertilizer use and high school education were significant determinants of the decision (participation) and use intensity (consumption).

A study on the farmers' technical knowledge, communication and adoption behavior on rice production technology package in Pyinmana Township in Myanmar was studied by Nyein Nyein Htwe (2000). The results revealed that age of the farmers was negatively correlated with the adoption of all selected technologies in both monsoon and summer rice. Almost all of the adoption of farm practices were positively related to educational level of the farmers in both monsoon and summer rice. Family size of the farm household was positively and significantly related to the use of HYV in monsoon rice. Positive relation was found between the adoption of all selected technologies and social participation. Contacts with extension agents and involvements in extension activities were positively related to the adoption of most of the selected farm practices.

Tin Cho Cho Myat (2004) studied the extent and the adoption decision of the improved sugarcane technology on Pyinmana, Yedarshe, Taikkyi and Pyay in Myanmar. Farmers' education, cane yield, distance from the government credit received were significant factors influencing the adoption of this technology. In addition, inadequate availability of HYV (28%), high cost for cane production (18%), needs of too much labor (13%) and lack of sufficient capital (13%) were cited as major reasons provided by nonadopters to adopt the improved technology. Less profitability than the other crops (30%), high cost of cane transportation (16%) and unavailability of subsidy (13%) were major constraints for widely cane production.

Similarly, Thinn Thinn Aye (2004) studied the extent and factors affecting the adoption of improved cotton production technology packages by pre-monsoon cotton farmers in Meiktila Township in Myanmar. The results showed that level of education, land fragmentation, use of hired labor, annual income and attendance in farmers' meeting were significant factors affecting the adoption of improved cotton production packages. Among the significant factors, land fragmentation had negative impact on the adoption of technology packages. The major constraints to obtain 400 viss per acre (1,620 kg ha^{-1}) of cotton were shortage of improved seeds (78%), credit needed for high investment (64%), unavailability of insecticide in right time (60%) and shortage of irrigated water (58%). Moreover, increasing the number of farmers' meeting program and intensive use of labor would increase the adoption of improved cotton production technologies.

Finally, L. Seng Kham (2009) concluded that modern maize variety growers were classified as significantly less use of seed, more use of credit, younger age, higher annual income and larger maize cultivated land than traditional maize variety growers in Kyaukme Township in Myanmar. While in Kyaukme, the variables of farmers' farming experience, use of chemical fertilizer and maize yield showed the largest negative value coefficients and they were important in placing traditional maize variety growers group. This meant that traditional maize variety growers were categorized by less use of chemical fertilizer, less yield and less farming experiences. Likewise Lashio Township, the average values of technical factors of maize yield, use of chemical fertilizer and total human labor were observed significantly higher in modern maize variety growers.

2.3 Use of logit and multinomial logistic models in adoption studies

Variants of the logit model include the ordinary logit (binary logit), the ordinal logistic, nominal logistic and the 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.

Logit model has been widely used in different adoption studies (for example, Yahanse *et al*., 1990; Polson and Spencer, 1991, Weingsang, 1996). These models not only help to assess various factors that affect the adoption of given new hybrid maize varieties, but also provide predicted probabilities of adoption. For example, they can be used to indicate how the likelihood of a farmer adopting a particular technology changes according to his or her level of education, keeping all other factors constant. To adopt or not to adopt technology is a discrete choice. Discrete choice econometric models have been widely used in estimating models that involve discrete economic decision problems (Guerre and Moon, 2004).

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 (Hosmer 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 decisions (Zhou *et al*., 2008, Sarwar *et al*., 2007, Nkamleu and Manyong, 2005, Namara *et al*., 2003). In this model farmers are assumed to make adoption decisions 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 indicator.

The advantage of multinomial logit is that it permits the analysis of the adoption decisions across the various soil fertility management alternatives – allowing the determination of choice probabilities for different categories of soil nutrient management practices. This approach is more appropriate than probit or logit models which have been conventionally used in studies of farmer's adoption of soil fertility management practices (Hailu 1990; Daramola 1989), when there exist multiple soil nutrient management strategies. Because the multinomial logit model does not treat these nutrient management categories in any continuous order, it is different from ordered logit or probit models (Ameniya, 1981).

Moreover, the advantage of using a multinomial logit model is its computational simplicity in calculating the choice probabilities that are expressible in analytical form (Tse, 1987). This model provides a convenient closed form for underlying choice probabilities, with no need of multivariate integration, making it simple to compute choice situations characterized by many alternatives. In addition, the computational burden of the multinomial logit specification is made easier by its likelihood function, which is globally concave (Hausman and McFadden, 1984).