CHAPTER 2

LITERATURE REVIEW

This chapter provides a review of some literature on sustainable agriculture, coconut based farming systems, and the factors influencing the sustainable farming systems. Further this takes an attempt to discuss an appropriate statistical method, ordered probit model dealing with the analysis of factors influencing sustainable coconut-based smallholder farming systems in Sri Lanka.

2.1 Coconut cultivation in Sri Lanka

It has been reported that coconut cultivation sustains the livelihood of large numbers in the tropics and is the most important crop for food security after rice in Sri Lanka. The country has the highest annual per capita consumption (110 nuts) of coconuts in the world. Sri Lankans dedicate about 400,000 hectares, more than a fifth of the agricultural land in the country to grow the crop. These efforts produce an average of 2.5 billion nuts every year, which account for 2 percent of Sri Lanka's gross domestic product, 2.5 percent of its export earnings and 5 percent of its workforce (IRI, 2003). The coconut industry has provided about 700,000 job opportunities and brings nearly 20 billion rupees to the country annually through exports (CDA, 2009).

The small farm is a major feature of land tenure systems in the developing countries. In Sri Lanka smallholder coconut farms account for about 90 percent of the total area. 87 percent of holdings are less than 2.02 hectares and out of that 58 percent are less than 0.8 hectares (FAO, 1995).

Due to the limited size of the smallholder fields, the small number of trees, the limited labour requirement of the coconut crop and the limited returns provided, most families cannot survive on the income from the coconut crop. Aguilar and Bernard (1991) indicated that the problem of low income in the smallholder coconut production sector can be attributed to several factors, some of which are within farmer control and some beyond. Those are unstable prices of coconut products, declining productivity of coconut trees due to senility and non adoption of recommended coconut management practices, underutilization of coconut farms due to tenure problems and absence of or ineffective support services or credit and their combinations. For the exposing towards the agro forestry to improve soil fertility, size of land and labour were some of the constraints faced by farmers (Ajayi, 2006). Red weevil, nut mite, black beetle and plesispa beetle damages and tapering and leaf spot diseases are the common pest problems prevailing in coconut cultivations in Sri Lanka which affect on yield reduction (CCB, 2006). Out of all red weevil is the most dangerous pest which is a concealed tissue borer of palms and reported from 15 per cent of the coconut growing countries mainly from tropical South and South East Asia creating fatal condition to coconut plantations (Faleiro and Kumar, 2008).

2.2 Sustainable agriculture

In the early 1980s, a new theory of sustainable agriculture was proposed for the sustainable development of global agriculture (Quin and Xueping, 2007). At present sustainability is not a new concept but rather a prominent concept (Praneetvatakul *et al.,* 2001). McConnell and Dillon (1997) defined sustainability as a capacity of a system to maintain its productivity and profitability at a satisfactory level over a long or indefinite time period regardless of year- to-year fluctuations. Further, sustainable agriculture integrates three main goals: environmental health, economic profitability and social and economic equity. Other than that favorable attitude and perception of farmer towards soil and water conservation and environmental protection help for the adoption of sustainable practices.

Agriculture, especially in developing countries emphasis on achieving higher productivity with little regard for sustainability. Due to that large areas of the world have faced severe soil degradation, erosion and natural resource depletion. Hosseini (2011) viewed the sustainable agriculture as a 'moral' system approach comprises social, environmental and economic dimensions which consider impact of agricultural practices on local ecosystem and the global environment. Moreover, social factors such as extension, education and knowledge of farmer influence the sustainable agriculture.

2.3 Policy dealing with sustainability

Sri Lanka possesses ample lands which are either degraded due to unsustainable agricultural practices or otherwise sparsely used. These lands can be used for multiple benefits by enhancing year round utilization with efficient resource usage (Jayasinghe, 2011).

In Sri Lanka sustainable agriculture policy aims to establish a farming system considering environmentally and economically sustainable and socially just criteria. In plantation crop cultivations, due to efforts made in getting maximum yields using monocrops, there has been a serious impact on environment and on the economy. As a result the country is losing the genetic diversity that had inherited earlier. The diversity of indigenous agriculture is being lost too. Therefore the sustainable policy mainly concerns the diversification of farms to improve sustainability (Weerakoon, 2009).

2.4 Sustainable farming systems and practices

Farmers have the ability to choose production practices and farming systems that maintain the ability of agriculture to produce agricultural commodities and products for decent standard of living without exploiting the ability of future farmers to produce and maintain a decent standard of living and quality of the environment for current and future generation. There are no farming systems that are completely environmentally benign. All have some potential consequences on the environment (Damghani *et al*., 2009).

Sustainable farming system can be defined as one that is economically viable, environmentally sound and socially acceptable. This can be an integrated system of plant and animal production practices that will satisfy human food and fiber needs, enhance environmental quality and natural resources base, make the efficient use of non-renewable resources and integrate natural biological cycles and controls, sustain the economic viability of farm operations and enhance the quality of farmer's life and society as a whole. Furthermore a farming system cannot be labeled either conventional or sustainable and have to be considered in relative terms. Sustainability is determined by the system as a whole, not its individual components (http:/www.uky.edu/deberti/test/sus.htm).

Sustainability in a farm can be implemented through intensification of land use by introducing integrated agriculture with agro-forestry, soil and water conservation and soil fertility improvement by organic fertilization, using available waste in the land (Ahmad, 2001)

2.5 Coconut-based farming systems

In Sri Lanka, coconut Research Institute has introduced different sustainable agricultural practices for farmers to improve the sustainability and productivity of the land. There are three systems called monocropping which is considered as comparatively less sustainable since only coconut is grown alone and intercropping and livestock integration systems are more sustainable than monocropping since those are diversified systems.

Monocropping

Monocropping is the growing only a single crop (coconut) in a given land area. It reveals that coconut monoculture utilizes biophysical resources sub-optimally. In a mature coconut plantation, nearly 75% of productive land area remains unutilized, because coconut has to be planted at a wide spacing of 7.9 m x 7.9 m allowing proper canopy growth and root distribution at maturity. Only 44% of the available sun light is utilized by the plantations at maturity and in economic terms too, monoculture coconut brings low returns per unit land area. It further suggested that investment in mixed farming is more beneficial than the adoption of monocropping. Coconut monocropping is well known as a "lazy man's system" because its less-intensive utilization of labour (Peiris *et al*., 2003).

Monocropping stands of coconut cover the ground partially exposing soil for direct sunlight and rainfall. Due to that erosion and soil degradation can occur especially when the palms are young. Therefore it is a common sustainable management practice to adopt soil and water conservation practices such as terracing, preparation of contour drains and bunds and burying coconut husks in pits and trenches near the palms (Liyanage *et al*., 1986). While monoculture farming has advantages in terms of efficiency and ease of management, the loss of the crop in any one year could put a farm out of business affecting and the stability of a community dependent on that crop undesirably (CRI, 2006)

Intercropping

Diversified farms are usually more economically and ecologically resilient. By growing a variety of crops, farmers spread economic risk and are less susceptible to the radical price fluctuations associated with changes in supply and demand. A sound strategy for competitiveness is coconut-based farming system comprising two elements: replanting with good clones; and market-based intercropping with other crops. Ohler (1999) explained that most of the annuals, biennials and perennials tried in coconut-based multiple cropping systems are compatible with coconuts. Most of them found beneficial to coconut productivity because of consequential site enrichment and their productivity was often comparable to that when grown in the open. Hence, the coconut-based cropping systems are capable of improving the financial status of smallholder farmers, while permitting them to use available resources more efficiently. But the success of these systems depends on the choice of component species and the availability of suitable shade-tolerant varieties of these species, time of planting, labour resources, access to capital and market outlets, price behaviour, availability of irrigation facilities in dry season and the theft problem. Nevertheless, the crop mix is better for smallholder coconut farming than monocropping.

In the Philippines and other parts of Asia, intercropping with annuals is considered more appropriate, since most landowners do not allow planting of perennials between coconuts. In newly established coconut plantations, intercropping with annuals may provide quick cash returns to provide some income when the palms are not yet bearing. In flat land and gentle slopes certain species of annuals can provide good ground cover, minimizing erosion and improving moisture retention. However, the major drawback of annuals as intercrops is their need for continuous cultivation, which is labour-intensive and most annuals are adversely affected by shade (Ohler, 1999).

Parrotta (1993) reported that in India, high-density multispecies cropping systems have been developed under coconut with bananas, papayas, yams and pineapples. In Panama, coconut is commonly planted in mixed perennial cropping systems with bananas, avocados and plantains. Perennials are particularly suited to intercropping with coconut because once they reach maturity they continue to provide a steady flow of income with little maintenance requirements. This is also considered important under smallholder production systems where resources are limited and family labour is limited for maintenance and supervision of fields. Ohler (1999) viewed that although many perennial crop species are known to grow well under coconut research on their compatibility and economic viability has been conducted on only a few of them. Asia and the Pacific, more work has been carried out on coconut intercropping with annuals than with perennials.

In Sri Lanka, intercropping has been introduced to coconut plantation in 1978-1980 periods. Since the coconut monocropping has been identified as an inefficient and low productivity system intercropping has proven to be the best option for maximizing land use. It has been estimated that about 200,000 ha of plantations mainly in the Wet and Wet-Intermediate zones have the potential for intercropping. Age of the palm, soil moisture and fertilization, choice of intercrop, rainfall, and labour requirement are the main considerations for successful intercropping (CRI, 2006). A study by Liyanage *et al*. (1986) revealed that intercropping in coconut stands resulted in a 300 percent increase in on-farm employment. Depending on the type and number of intercrops grown, the requirement of labor and share of labor cost in the total cost of production vary.

Moreover, higher income and profit, maximization of resources use efficiency, increases of coconut production, improving of soil fertility and land productivity, minimization of risk of dependency on one crop and food security are the benefits achieved by smallholder farmer by intercropping their monocropping fields (CRI, 2006). Thus intercropping can be a better way for increasing the sustainability of coconut lands.

It has been investigated that in the Wet and Intermediate zones, bananas, black pepper, coffee and ginger are the most preferred intercrops by smallholder farmers in Sri Lanka while the secondly preferred group of crops are turmeric, pineapple, vegetables and betel. Furthermore profitability, marketing facilities and convenience are the factors considered by the farmers for selecting intercrops (Liyanage *et al*., 1986).

There may be a competition when intercrops are introduced to coconut due to overcrowding of plants. There will be negative interaction leading to adverse effect on the main crop (coconut) and the intercrop. Such effects are likely to arise if the intercrops are not properly managed. Therefore increasing the inputs of resources such as fertilizer and moisture, or reducing the densities of the crops could be useful to minimize the competition of crops (Peiris *et al*., 2003: Liyanage *et al*., 1986).

Coconut – livestock integration system

Livestock make a significant contribution to the livelihood of coconut based households and offer substantial scope for poverty reduction in coconut growing communities (Bansu and Dery, 2009). Over 90 percent of coconut is grown by smallholder farmers and forage cultivation and cattle raising under coconut is becoming one of the methods by which the tree leaves, cut and carry forage from on and off farm are utilized in the system. In addition, with livestock feeding systems based on banana leaves and stems, sugarcane and Napier grass, smallholder farmer can increase his income and food supply. Various crop residues, weeds, Leucaena, Gliricidia, rice straw, copra cake, rice bran as well as various conventional grasses and legumes have already given promising results in many countries such as Bangladesh, Colombia, India, Indonesia, Ivory Coast, Kenya, Malaysia, Philippines, Seychelles, Tanzania and Sri Lanka (Ohler, 1999).

Ahmad (2001) observed that integration farming has been promoted efficiently among Malaysian farmers by incorporating short term crops such as pineapples, chili, maize, livestock rearing especially sheep and poultry, apiculture and mushroom cultivation with perennial crops and forest trees. With this regard, veterinary services have been developed to maximize the use of rubber, oil palm, cocoa and coconut lands by introducing mixed farming on existing land in an effort to increase land productivity and income of smallholder farmers.

Paulet (2011) viewed a system like livestock integration is a valuable risk management tool in this period of increasing volatility in our agricultural commodity markets. A good rotation is the key to any livestock integration production system which helps to manage weeds, pests and diseases. A good rotation will improve soil structure and fertility too. Livestock integration usually requires a significant level of capital investment to successfully set up and run these business structures.

Payne (1985) reported that the cattle-coconut integrated system is the widely developed system in the tropics than any other integrated systems. This system can improve productivity per unit land area that is an important issue in a world where the total population is increasing rapidly limiting the availability of land for agriculture. This enhances the diversification of product output and labor input at the same time controlling weeds in the coconut plantation. Although integration livestock with crops has many advantages this has not become the most common system due to many reasons. Requirement of higher standard of management, additional infrastructure, capital and labor and lack of practical experience are the main problems not to adopt this system by smallholder farmers.

In Ghana, Bonsu *et al.*, 2009 viewed that coconut farmers treat their livestock as a livelihood security and not for profit. It is generally based on traditional and socioeconomic considerations with locally available feed resources. However poor livestock keepers obtain benefit in diverse ways and on a sustainable basis. Provision of veterinary training and services is essential for the success of smallholder livestock keeping.

It has been evaluated that cultivation of coconut integration with cattle and poultry (livestock) and mix cropping with banana and vegetables 26,076.50 rupees of annual income could be obtained from a farm in Puttalam district in Sri Lanka (FAO, 1995). Reynolds (1995) identified that cattle have been used as sweepers or brushers keeping the grass and weeds short, preventing excessive nutrient and moisture competition with the coconut palms and ensuring easy location and collection of fallen nuts.

However, rearing of livestock under coconut is not as popular as intercropping mainly due to lower economic returns, higher capital and operational costs and due to social problems associated with livestock keeping (Ohler, 1999).

2.6 Sustainable farming practices in coconut-based systems

Many sustainable technologies have been introduced to coconut-based systems to improve the land productivity and sustainability.

Moisture conservation

Moisture in soil improves the capability to absorb nutrients resulting in proper growth and higher nut production. Research showed that clay and organic matters hold the water in the soil and higher content of organic matter in the soil increases the moisture holding capacity. Therefore measures have to be adopted in coconut growing land to maximize the volume of rainwater to be absorbed into the soil sub layers without allowing it to run-off the land. When the rainwater collection and movement is properly managed the productivity of the land can be increased effectively. The measures taken for this purpose in coconut land are establishment of cover crops, burial of coconut husks in pits, mulching on the manure circle and contour drains and bunds (Admin, 2009).

Based on a research finding by CRI of Sri Lanka Abeygunawardena *et al.* (1995) recommended burying of coir dust in pits (particularly in lateritic gravel soils) and coconut husks in pits (particularly in sandy soils) hopefully increase coconut yield. Therefore the coconut producers are encouraged to adopt moisture conservation measures in their lands to obtain better yield from coconut palm.

The husk can either be piled at the base of the coconut trunk as mulch, or chopped and composted. A layer of husk with the convex side upward is placed 2 meters away from the base around the tree to minimize the loss of moisture and heavy growth of weeds (Mantiquilla *et al*., 1994). Soil conservation structures such as drains and waterways are integral part of a farm. Structures such as bench terraces and silt pits conserve the land and control soil erosion too. Other than that cover crops, mulching and contour planting like techniques can also be beneficial (Ahmad, 2001).

Integrated Nutrient Management (INM)

Healthy soil is a key component of sustainability. In sustainable systems, the soil is viewed as a fragile and living medium that must be protected to ensure its long-term productivity and stability. To enhance the productivity of soil regular addition of organic matter, cover cropping, reduce tillage and mulching can be practiced. These practices increase soil aggregate stability, soil tilth and diversity of soil microbial life.

Organic fertilization is indeed a versatile component in a coconut-based farming system and a cheaper source of nutrients. If this is realized by the coconut farmers, the use of coconut fertilizer may reduce the cost of their farm inputs, and thus, help increase net profits and conserve the dollar reserve of the country. Palms grown in sandy soils, on the other hand, responded to the application of inorganic fertilizer with extra goat dung. The nut production increased by 42 percent while copra production by 45 percent at the end of the 5th year (Mantiquilla *et al*., 1994).

Gunathilake (2005) and Rosa (1993) stated the importance of using Gliricidia as a green manure crop in coconut. Gliricidia, when intercropping with coconut, controls weeds, improves soil structure through leaf fall, increases copra yields and provides fodder and fuel wood. A research on coconut fertilization with Gliricidia and without Gliricidia leaves showed that total annual urea requirement and 50 percent of the Eppawala Rock Phosphate (ERP), Muriate of Potash (MOP) and Dolomite requirements can be reduced by incorporating Gliricidia 50kg per palm per year.

Chicken droppings are the most popularly used organic fertilizers in vegetable and fruit fields by smallholder farmers in Malaysia to fertilize marginal lands in addition to inorganic fertilizer. In addition to that empty bunches of oil palm are also added (Ahmad, 2001).

Replanting

An aggregate of several factors needs to be considered when rejuvenation is undertaken in coconut lands particularly age and yield. If the age of the majority of palms is more than 60 years and if the yield is less than 1000 nuts per acre per year despite average management, then the plantation is due for replanting or underplanting. Based on experimental data replanting has proved superior to underplanting. Replanting is recommended for large-scale plantations but for small holder farmers, underplanting is allowed due to financial constraints. Yet a large proportion of the capital investment incurred in establishment could be obtained at the initial stage itself by the sale of coconut trunks, when complete removal is undertaken (CRI, 2010)

Underplanting

Gradual removal of the old plantation within a 5-6 year period is preferred by most growers due to the advantage of obtaining the yield from the remaining old palms. The new planting points are marked in the center of the old square. First very weak palms and palms within a minimum distance of 8 feet from the newly marked planting points (20 percent generally) are removed. Then the remaining palms are removed gradually each year by 15 percent during first two years, by 20 percent in another two years and remaining palms in the 5th year. If annual removal is difficult, thinning can be carried out biannually by 30 percent and 40 percent during 4 years and remaining palms in the 6th year (CRI, 2010).

2.7 Factors influencing sustainability

D'souza *et al*. (1993) stated that the factors influencing to adopt the new technologies vary among farmers. The identification of the influencing factors is useful for policy decision-making because it facilitates the understanding of the circumstances under which promoting alternatives may have the farmers' greatest impact**.**

Making the transition to sustainable agriculture is a process. For farmers, the transition to sustainable agriculture normally requires a series of small, realistic steps. However, there are many obstacles for the diffusion of sustainable technologies so that the adoption of sustainable agricultural technologies lags far behind technology innovation. Therefore economic conditions specially farm family economics and personal goals influence how fast or how far participants can go in the transition. It is important to realize that each small decision can make a difference and contribute to advancing the entire system. It is needed to recognize the characteristics of the early-adopters of sustainable agricultural technologies for policy implication (Ju-yong and Yong-hong, 2007).

Economic and social conditions play important roles in farmer choice decisions. It would be pointless to promote crops or techniques that do not meet the true interests of farmers or for which the needed resources are unavailable. Therefore, the search for technical options needs not only to consider socio-economic factors when designing new technologies but also needs to be complemented with policies and programs that alleviate socio-economic constraints (Baidu-Forson *et al.*, 1997).

Balanced use of inputs (recommended rates of chemicals), profitable and efficient production by diversification to reduce cost of production, application of resource conservation technologies and commodity and price support programs are essential to increase the productivity of small scale farms towards sustainability (Zhen and Routray, 2003). This will enhance the innovation ability of the farmer.

Knowledge is an important determinant in sustainability. Because this can be used to formulate policies or target specific groups of producers to promote sustainable agricultural technologies. Therefore it has been found out that education level of the farmer has a positive impact to follow sustainable practices (D'souza *et al.*, 1993). Educational programmes on agronomic and economic information to enhance the awareness of the farmer have a positive effect on sustainability (Alonge and Martin, 1995). Other than that favorable attitude and perception of farmer towards soil and water conservation and environmental protection help for the adoption of sustainable practices.

Agricultural extension can be considered as one of the important sources of information dissemination directly relevant to agricultural production practices. This reinforced by the fact that many studies find a significant influence of extension education on the adoption of land improving technologies (Rahman, 2008).

Age is likely to be negatively associated with adoption of sustainable technologies. D'souza *et al*. (1993) stated that younger farmers are more likely to adopt new technologies and more likely to be early adopters. Further it has been suggested that because sustainable agriculture involves the partial substitution of management for other factors of production and is therefore more time-intensive, it is more likely to be adopted by full-time farmers. Thus, the presence of off-farm employment on the part of the farmer is likely to be negatively associated with his decision of adoption. By definition sustainable agricultural systems rely on more natural processes and labour saving. Therefore hired labour utilization has been negatively influence on sustainable technologies. Size of the farm is most likely to have a negative effect in sustainability. Because sustainable agriculture does not have a scale effect like computers or tractors. Due to conversion of agricultural land to property development, the rapid growth and escalating land values threaten farming by discouraging farmers to adopt sustainable practices and a long-term perspective on the value of land (http://www.sarep.ucdavis.edu/concept.htm).

The main factors for unsustainability are the neglecting of land by the owners due to migration or displacement and lack of finance and technology for land improvement. Therefore it is important to identify this type of land for better management (Purasinghe, 2008).

Top soil depletion, ground water contamination, the decline of family farms, and disintegration of economic and social conditions in rural communities have been identified as the measures of unsustainability. Therefore the practices result in these conditions are considered as unsustainable. Conversion of agricultural land to urban uses has become a threaten for farming. This discourages farmers from adopting sustainable practices and a long term perspective on the value of the land. Urban influence on the land negatively affects on adoption decision. At the farm level, practices causing soil erosion considered as non sustainable (Zhen and Routray, 2003; Igsin *et al*., 2008).

Coconut-based farming systems are adopted by many small-scale farmers as a self-sustaining and risk- minimizing strategy because the productivity of the coconut land can be increased. It minimizes resource demand, especially under traditional farming practices where levels of resource endowments are low and where the farmers' planning horizon is limited. It has been identified that land use and management is a major factor contributes to the productivity of coconut lands by improving the efficiency and productivity through diversified cropping patterns (Zhen and Routray, 2003).

Ohler (1999) explained that since many traditional farmers are unwilling to cut down and replace over-aged palms, coconut tends to occupy land for a long time at the expense of alternative production. In this regard, coconut land can be better utilized adopting coconut based sustainable systems. In addition, it is important to adopt livestock integration coconut farming system to make coconut production worthwhile with encouragements of improved husbandry practices which increase the productivity of coconut land and enhance the viability of coconut ventures. The steady net cash-flow from coconut based systems acts as insurance to farmers and provides a genuine reward for the farmer's effort.

In spite of the positive reasons favoring, there are several fundamental problems that make it difficult for farmers to adopt coconut-based farming systems. Coconut farmers have a choice to make and decide on what enterprise to introduce on their farms. The adverse conditions and the social norms that often govern make difficult it often for them to introduce even the most viable enterprise options. Conservatism of traditional small-scale farmers, the unique social setting of the rural environment and the rather harsh conditions under which farmers have to operate have limited their scope to adopt coconut based systems. Land tenure problems, off-farm employment opportunities, farm size, labor supply, capital, product prices, input costs, and marketing infrastructure, which are associated with farming, also affect farmers' attitudes to fallow these systems. For a particular farming system to be acceptable it must fit within the socio-cultural, political and institutional environment of a society. In the Philippines and in Western Samoa, coconut farmers' welfare and attitudes to coconut technologies, indicated that over 80 percent of coconut farmers were smallholders with low education levels. Excluding coconut land, the average household size was over 6 persons operating on less than one hectare of land for their livelihood, with less per capita income (Ohler, 1999).

2.8 Use of ordered probit model in relevant research

Probit analysis developed from the need to analyze qualitative (dichotomous or polytomous) dependent variables within the regression framework. Many response variables are binary by nature while others are measured ordinally rather than continuously (degree of severity). Ordinary least squares (OLS) regression has been shown to be inadequate when the dependent variable is discrete and probit or logit analyses are more appropriate in such occasions (www.okstate.edu/sas/v7/saspdf/stat/chap5.pdf).

The ordered probit model is a fairly straightforward extension of the binary probit model. When the dependent variable takes more than two values have a natural ordering as is common in survey responses, the ordered probit model is more appropriate. This model can make full use of every response choice, is statistically more efficient than the binary probit model and that uses maximum likelihood analysis. Ordinal discrete choice estimation procedure, ordered probit, is used instead of ordinary least squares. An ordinal variable is a variable for which the categories can be ranked from high to low, however the distance between adjacent categories are unknown. Moreover when the dependent variable is ordinal the errors are heteroscedastic and not normal, thus violating the assumptions of ordinary least squares. Like the models for binary data, this concerns how changes in the predictors translate into the probability of observing a particular ordinal outcome (Jackman, 2000; Baidu-Forson *et al.*, 1997).

Ordered probit allows the analysis of multiple but discrete values of the dependent variable while maintaining the ordinal nature. A positive sign on the coefficient of a given independent variable implies greater likelihood (Conner *et al*., 2010). In this model the dependent variable is unobservable. The choices are based on a comparison of sentiment. If it is assumed that the errors have the standard normal distribution, N (0, 1), an assumption that defines the ordered probit model.

Ordered probit forms are often applied to a context where an agent such as an individual, household or decision maker chooses among a discrete set of alternatives (Nagarajan *et al.*, 2005). This model analyzed the determinants of millet diversity in marginal environments of India and the results revealed market facilities to access seed significantly influenced on millet diversity.

Using the ordered probit model in Greece by Ginius *et al*. (2006) found out the influencing factors for adoption decision on organic farming. From this study it was obvious that education, environmental awareness, accessing to information channels and networks, extension services and workshops helped farmers to access information to take adoption decision on organic farming. Thereby this approach provided with evidence on the potential impact of information acquisition on farmers' technological choices.

The conjoint analysis and ordered probit methodologies used to evaluate technical and socioeconomic factors that influence crop production decisions. Ordered probit procedures were used to estimate utilities for groundnut farmers in Niger by Baidu-Forson *et al.* (1997). This study revealed that the alleviation of market and credit constraints provide greater utilities to farmers than the availability of more productive groundnut varieties.

Nagenthirarajah and Thiruchelvam (2008) used ordered probit model to assess the farmers' knowledge level on pest management practices and socio-economic factors influencing the existing pest management practices in Vauniya District, Sri Lanka. It was found out that farming experience and social participation were positive and significantly contributed to farmers' knowledge on safe pesticide use and further identified that social participation and effective extension programs were important to improve farmers' knowledge on proper use of pesticides.