Chapter 2

Literature Review

2.1 Soil erosion and land degradation

Erosion is the major factor responsible for land degradation. It has been estimated that 5 ha of agricultural land in the world is lost every five minutes due to land degradation (Wolman, 1985, cited in Manife 1997).

The effects of erosion are not only confined on-site yield reduction, but also have off-site effects such as siltation of waterways and reservoirs (Bandusena, 1995, cited in Manife 1997), The siltation of reservoirs decreases the capacity to store water, thereby reducing the capacity for hydropower generation and irrigation.

Soil erosion is a major environmental threat to the sustainability and productive capacity of conventional agriculture worldwide. Indeed, during the last 40 years, nearly one-third of the world's arable land has been lost to erosion and continues to be lost at a rate of more than 10 million hectares per year.

2.2 Soil erosion status of mid country steep lands of Sri Lanka

Alwis and Dimantha, (1981) estimated that 30 cm topsoil has been eroded from upland areas over the past 100 years. This is equivalent to an average soil loss 40 t/ha/yr. Some estimates show that over the past centuries the highland region in Sri Lanka has lost as much as 300 mm of topsoils (Stokings, 1992, Krishnarajah, 1984, TAMS, 1980). (Table 1)

Table 2.1 Soil Erosion under Different Land Uses

Location and Land use/Cover type	Soil Loss (t/ha/year)
a. Mid-Country Wet Zone (Peradeniya)	
Soil Type: Reddish Brown Latasolic (Ultisols)	
Old seedling tea (No conservation)	40.00
Well managed clonal (VP) tea planted on contour with lateral drains at 10m intervals	24.00
Mixed home gardens with assortment of tree crops with heavy canopy	0.05
b. Up-Country Wet Zone (Talawakelle)	
Soil Type: Red Yellow Podzolic (Ultisols)	
Bare, clean weeded one year old clonal tea	52.60
One year old clonal tea with mulch	0.07
c. Mid-Country Intermediate Zone (Hanguranketa)	
Soil Type: Immature Brown Loam (Inceptisols)	
(Slope: 40%)	
Tobacco with no conservation practice	70.00
Capsicum with no conservation	38.00
Carrots with no conservation	18.00
d. Low-Country Dry Zone (Maha-Illuppallama)	
Soil Type: Reddish Brown Earths (Alfisols)	
Sorghum/ Pigeon pea under clean cultivation	21.30
Sorghum/ Pigeon pea with 1500 kg/ha mulch	3.90
Cotton under clean cultivation	22.20
Cotton with mulch 3500 kg/ha	2.00

Source: Stocking (1992), Krishnarajah (1984), TAMS (1980)

Soil erosion is a serious environmental problem in Sri Lanka and it has been controlled if the avowed aim of sustainable agriculture is achieved. Several micro and macro level studies have shed light to the seriousness of the problem. It is believed that part of growth in the agricultural sector in Sri Lanka has led to resource degradation, with the adverse implication on sustainability of future agricultural growth. Land degradation particularly soil erosion is more prominent in the areas of steep lands of central hilly region (Kotagama, 1998).

Soil erosion has direct on-site effect of reduced crop productivity due to fertility decline and degraded soil structure. Further, it has off site effects such as reduction in quantity of water availability for down stream and reduced irrigation and hydropower generation capacity due to reservoir siltation (Bandara and Coxhead, 1995). According to MASL (Mahaweli Authority of Sri Lanka) the predicted volume changes in three reservoirs and the monitored sedimentation rates of reservoirs and sediment yields from different catchments shown in Table2 and Table3. Most annual crops grown on sloping lands, including many widely grown food crops, tend to generate a high rate of soil erosion (Stokings, 1992, Bandarathilke, 1995).

Table 2.2 Predicted Volume changes in Kotmale, Victoria & Randenigala

Reservoir	**% of Trap efficiency**	**Annual sediment inflow Mm^3**	**# Years to reduce to 90% of original value= 10% Loss of volume**
Kotmale	92	0.386	52
Victoria	93	0.636	113
Randenigala	93	0.70	113

Source: EFCD/MASL (1995)

Table 2.3 Sedimentation rates of reservoirs and sediment yields from different catchments

Catchment	Area (km^2)	Yield (t/ha/y)	Source	Remarks
Kotmale	550.00	4.16 3.36	Nadeco (1992) Russels (1992) (HAO&M) MASL (1992)	11% (1.8 Mm^3) volume to be silted up in 5 years No appreciable change in volume < 1%)
	60.50	0.60	EFCD/MASL (1995)	
UMC above polgolla	1292.00	3.90	HAO&M/ MASL (1993)	Polgolla- 44%
Victoria	1891.00	3.40	Nadeco (1984) HAO&M/ MASL (1994)	Nedeco-1 MCM (76-93) -2.2 MCM
Maha Oya at R.B Tributaries	476.00	9.40	Nadeco (!994)	
Rantembe Uma Oya Above-Welimada	2378 740 94	2.1 14.8 10.6	HAO&M/ MASL (1992,1994) EFCD/MASL (1994)	4-6% loss of volume annually

Most annual crops grown on sloping lands, including many widely grown food crops, tend to generate a high rate of soil erosion (Stokings, 1992)

Table 2.4 Field Observation on soil erosion rates

Slope (%)	Land use	AEZ	Soil erosion rates (t/ha/yr)	Top soil removal (mm/yr)	References
15	Onion and bean no conservation	IM3	70	5.0	Stockings (1992)
22	Tobacco no conservation	IM3	100	7-14	Stockings(1992)
30	Vegetable no conservation -With contour hedgerow	IM3 IM3	130 3	9.0 0.2	Stockings(1992) Stockings(1992)
40	Tobacco with no conservation	IM3	70	5.0	Krishnarajah (1984)
40	Capsicum with no conservation	IM3	38	2.6	Krishnarajah (1984)
40	Carrot with no conservation	IM3	18	1.3	Krishnarajah (1984)
45	Bitter gourd no Conservation	IM3	200	14	Stockings (1992)
50	Bush beans no conservation	IM3	>200	>14	Stockings (1992)

Source: Stokings (1992)

TAMS/USAID (1980) reported an estimated soil loss of 388-913 t/ha/yr on poorly managed tobacco cultivation in the Maha Oya river basin in mid country intermediate zone, where slopes ranged from 30-60%. The technique used was USLE using factor values derived from the USA (Table5).

Table 2.5 Soil erosion rates in poorly managed tobacco in IM3

Location	Soil	Slope (%)	Soil Loss (t/ha/yr)
Mailapitiya	Red Brown Loam	45	388
Mailapitiya	Red Brown Loam	55	486
Mailapitiya	Imm:Brown Loam	50	719
Moragahamulla	Imm:Brown Loam	35	411
Kande Junction	Red Brown Podzol	60	913

Source: Joshua W.D. (1977)

Soil degradation due to human activities is a major threat to the soil resources at present. Nayakekorala *et al* (1995) reviewed the soil degradation status of the country. And reported that soil erosion, fertility decline, pollution (addition of toxic materials to soil), salinisation/alkalization, desertification (lowering of soil acidity), eutrification (increase of certain nutrients impairing plant growth), and water logging were responsible for soil degradation in Sri Lanka. Soil erosion and fertility decline (Table6) were the serious problems. Salinization, desertification and eutrification processes are also important in some areas. Rates of soil erosion, nutrient loss and sedimentation rates of the reservoirs have been reported by Krishnarajah, (1984), Stocking (1992), Yatawara (1996), Wallingford (1995), and Nayakekorala (1997).

Table 2.6 Fertility loss per period in terms of rupees from land without soil conservation

Location	Period	Soil Loss (t/ha)	Calculated loss of N (kg/ha)	Estimated Cost For N Replacement (Rs)	Available P in Sediment (ppm)	Exchangeable K in Sediment (ppm)
Mulgama (IM1)	93 Sep-94 Feb (6 months)	60	135	3,100.00	-	-
Moragahamula (IM3)	93 Oct-93 Feb (5 months)	26.1	30	750.00	16	87.98
Adikarigama (IM1)	93 Sep-94 Feb (6 months)	22.4	45	900.00	26.5	84.1
Mahaberiyatenna (IM3)	93 Sep-94 Feb (6 months)	43.7	135	3,100.00	17	60

Source: EFCD/MASL (1994)

According to the available soil erosion data, erosion is severe in seedling tea, tobacco, potato and vegetable cultivation in the mid country intermediate zones and in rainfed uplands in dry zone. Erosion is severe in areas under slash and burn “chena” cultivation. (Gamage, 1999).

One study of poorly managed tobacco in the Maha Oya basin found soil losses of 388-913 t/ha/y. Such estimates, of how a particular land use erodes soil do vary a great deal, both within and across studies, because slope, soil type and rainfall vary across the samples. For example, Stocking’s highest erosion estimate is 200 t/ha/y soil losses for a plot of beans. Grootveld’s highest is 100 t/ha/y soil losses for a market garden plot. Despite these variations, the rankings across land uses are fairly clear, as are the orders of magnitude. Stocking gives an Erosion Hazard Rating (EHR) of 40 to

Table 2.7 Stocking' s Erosion Hazard Rating for the different land uses

Stocking's Erosion Hazard Ratings (EHR)for the Upper Mahaweli Catchment		
Land Use	Subcategory	EHR
Tea	Mature seedling or v p tea: >80% cover	1
	60-80% cover	2
	40-60% cover	4
	<40% cover	32
	First year of new plantings	30
	First six years of new plantings	12
Perennial Crops	Kandyan Forest Gardens	0.1
	Minor Export Crops	2
	Other Plantation Perennials	1
	If intercropped with annual crops	30
Seasonal Crops	Paddy	0
	Chena- one year in 5 cultivation	6
	Upland Rain fed Crops in a cultivation year	40
	Upland Rain fed Crops in a fallow year	2
	Vegetables on slope with no conservation	40
	Vegetables with drains on an angle to contour	20
	Vegetables on bench terraces	0.2
	Tobacco on uplands	40
	Tobacco on paddy lands	0
Plantations	Eucalyptus	1.5
	Pine	2
	Other Species	1.5
Vegetation	Natural Woodland (dense)	0.1
	Natural Woodland (dense)	0
	Scrub	1
	Grassland (good cover)	1
	Grassland (<40% cover)	10

Source: Stocking (1992)

tobacco and taking instead the high end of the range of soil loss estimates, for which EHR 1 is equivalent to 24 t/ha/y. Tobacco and market gardens contributed to a soil loss 960 t/ha/y. For those highly erosive land uses, on the high estimates, almost 10 cm of soil would be removed each year. For the Wickramasinghe soil 70 cm of A-horizon and 110 cm of B-horizon could be swept away in less than a decade! At the more plausible and conservative estimates, the process would still only take several decades to erode the A-horizon to zero. (Minifie, 1997) (Table7).

2.3 Effects of introduction of soil conservation methods in the region

Under recommended soil conservation practices such as stone and bench terracing and the hedgerow system, soil erosion is very low. Therefore, nutrient losses are considered negligible under recommended soil conservation practices (Nayakakorale, 1999).

The introduction of soil conservation measures reduces the yield loss due to erosion. Gunatilake and Abeygunawardena (1993) presented the yield changes under different conservation practices after 10 years of introducing soil conservation measures. According to them, lock and spill drains, bench terraces and stone terraces improved the yields of tobacco, carrot and capsicum considerably.

It can be seen from Table 8, (Stockings, 1992) that erosion rates vary with slope and can be reduced by investment in erosion control. It can be seen that sloping agricultural land technology, or SALT, reduces erosion by 50 to 60 percent. SALT entails planting contour hedgerows to conserve soil, so that over time terraces build up above each row; it builds terrace without large initial construction expenditure; it can also be modified to reduce exposed soil area and further slow erosion. (Minifie, 1997)

Table 2.8 Erosion rates multiplying factors by slope and conservation measures

	Multiplier factors
A thin layer of fallen leaves covering bare ground, with evidence they are burnt or washed away frequently	4
Bare soil almost continuously under trees	6
SALT on steep vegetables/tobacco plots, with well-maintained double rows of barrier hedges at the recommended distance	0.1
SALT on tea lands during replanting, with barrier hedges and lock-and-spill drains on hillside ditches	0.5
Slope class 0-2%	0.02
Slope class 2-8%	0.05
Slope class 8-16%	0.25
Slope class 16-30%	0.50
Slope class 30-60%	1.00
Slope class 60 %	1.4

Source: Stokings (1992)

2.4 Farmer perception on soil erosion and conservation measures

Unlike other technologies, farmer decision making in adopting and implementing soil and water conservation practices is heavily dependent on physical, institutional, social and economic factors.

Two factors are important when considering the effect ecology has on adoption of conservation practices: (1) actual soil erosion conditions, and (2) perception of those conditions. Research findings are mixed, perhaps because of the variability in research techniques and the research definition of the erosion problem. Some researchers have calculated erosion rates on study farms, using the Universal Soil Loss Equation (USLE), while others have accepted the farmer's evaluation of erosion conditions. When the USLE was used to evaluate erosion, one study found that soil erosion was not a significant explanatory variable relative to adoption of practices (Nowak and Korsching, 1981, cited in Ervin and Ervin, 1982). Another study found a significant relationship between erosion potential and a farmer's effort in reducing the erosion problem (defined as the difference between the worst erosion possible and actual erosion) but not to the number of conservation practices used (Ervin and Ervin, 1982).

Variations of the impacts of these factors are depends on decision taking by the farmers. Whether or not to include soil conservation in their land management strategies, accounts for the difficulty in targeting technology packages that would be socially acceptable and, at the same time, economically viable from the point of view of the farmers (Garcia, 2001).

Awareness of soil erosion was relatively high, but farmer perception of soil erosion as a problem varied, while differences in farmers' knowledge influenced perception of soil erosion. The main reason for this is the differences in soil and farming conditions, e.g., in fallow systems there is less need for soil conservation whereas with continuous cropping, soil erosion is more likely to be a problem. Perceptions of erosion clearly had an effect on adoption behavior. In Salogon, for example, most farmers were aware of soil erosion and its effects, but none saw it as a significant problem. Also, there was no indigenous soil conservation technology as such. Perceptions of and attitudes to the recommended technologies appeared to be well informed, based on farmer's observations over several years at the project sites. Adopters and non-adopters shared perceptions regarding the labor requirements for establishing and maintaining the technologies, the loss of cultivable area, and the delay in obtaining benefits, as well as the undesirable side effects of some forms of hedgerow on weeds, pests, and diseases (Garcia, 2001).

Nevertheless, contour hedgerow technology, in particular, was widely seen (at least by project villages) as useful and necessary, easy to learn, and easy to acquire (though acquisition of planting materials was clearly a problem in some cases) (Garcia 2001).

Beyond project villages, however, there was very little awareness or knowledge of the recommended technologies, particularly of methods of implementation, indicates that diffusion does not readily occur without further organized extension activity (Garcia 2001).

Understanding the decision making process of the farmers with regard to soil erosion abatement is an essential take off point in the development of policy instruments that will achieve conservation objectives.

The methodologies that are used in introducing soil and water conservation techniques should very much attractive to the farmer, because benefits of most of the conservation measure not tangible immediately. Subsistence farming in itself is believed to be an impediment to conservation because resource poor farmers often find it difficult to invest in conservation effective practices especially since these types of investment are long term (Lal, 1993).

Most efforts to reduce soil erosion have included an educational component designed to make farmers aware of their erosion problem. These strategies implicitly assume that once farmers become aware of an erosion problem, they will take appropriate action. It is recognized that various social and economic factors influence the adoption process at a later stage, but their influence on perception of the problem has not been explored. This analysis indicates that perception of a soil erosion problem may be influenced more by social and economic factors than by the actual extent of the problem. Perception of environmental problems, therefore, is based not only on awareness, but also on the ability to do something about the problem. Therefore, structural constraints influence both the adoption of conservation practices and perception of an environmental problem. It is suggested that if an effective soil conservation program is to be developed, we must understand the unique problems, interests, and goals of farmers (Gary and Heffernan, 2000, cited in Garcia *et al* 2001).

2.5 Methodologies used for studying adoption process and their suitability

Generally three types of model can be used to measure binary response behavior. They are linear probability model, the logit model, and the probit model. The linear model has an obvious defect, as it is does not apply to the binary outcome that takes on the values of 0 and 1 (Amemiya, 1981; Collett, 1991). The binary decision also generates a non –linear response and thus violates the assumptions of the linear regression model; therefore a probability model based on a cumulative frequency distribution is used. The probability functions used for the probit and logit models are based on the normal distribution and on the logistic distribution function respectively and they are bounded between 0 and 1 and they exhibit a sigmoid curve, conforming to the theory of adoption (Sheikh *et al*, 2002). Logit and probit are same each other except at their tail (Ashton, 1972). However the tails of logistic models are flatter than the probit model (Amemiyas, 1981). In Tobit model, standard regression model, the dependent variable is generally assumed to take on any value within the set of real numbers and the probability of any particular value is zero. In the dichotomous probit model, the dependent variable assumes only two values, 0 and 1, each of which is assigned a probability mass. Proposed limited dependent variable model, later called the Tobit model by to handle dependent variable that are combinations of these two cases, specifically mass points at the low end called the limit value and continuous values above the limit (Garcia, 2001).

The logistic transformation is more convenient to compute. Unless there are other theoretical reasons for preferring a distribution function to the logistic cumulative distribution function, the logit model is preferred when repeated observations are available. The logistic model also has a direct interpretation (as does the probit model) in terms of logarithm of the odds in favor of success (Collet, 1991). Being based on the cumulative logistic probability function, the logit model can be used for transforming the dependent variable to predict probabilities within the bound (0, and 1).

The logit model assumes that the probability of an individual making a given choice is a linear function of the individual attributes (Pindyck and Rubinfeld, 1981). Adoption studies deal with individuals who are faced with a choice of whether or not to adopt a given technology, and often the choice depends on the characteristics of the individuals. The logit analysis was used in this study to predict the likelihood that a farmer will choose to adopt soil conservation technologies given information about his characteristics. The logistic model also has a direct interpretation (as does the probit model) in terms of the logarithm of the odds in favor of success (Collet, 1991). Being based on the cumulative logistic probability function, the logit model can be used for transforming the dependent variable to predict probabilities within the bound (0, 1).

First, the logit model was used to analyze the dependent variable adopt due to its dichotomous response outcomes, i.e. the farmer's decision takes the form of whether or not to adopt soil conservation technologies, hence the observed value of Y is either 0 or 1 (Garcia, 2001).

The choice of whether to use probit or logit model, both widely used in economics, is a matter of computational convenience (Greene, 2000). This model makes it possible to study the determination of the factors influencing soil and water conservation in the context of individually specific data on multiple choices.

2.6 Factors influencing the adoption of soil conservation technologies

In the past research, there were four main factors influencing the adoption of soil conservation technologies (Ervin and Ervin, 1982). The social factors, included as education of farmers, age, gender, household size, and skill and labor shortage. Tenure status, technical assistance, subsidies, marketing facilities and incentives are considered under institutional factors. Physical factors could be farm size, slope, access to road, soil quality, and rainfall pattern and other climatic factors, and vegetative cover. Main economic factors identified were farm income, availability of credit, off farm income, discount rate, input cost and risk and aversion. (Figure 2.1)

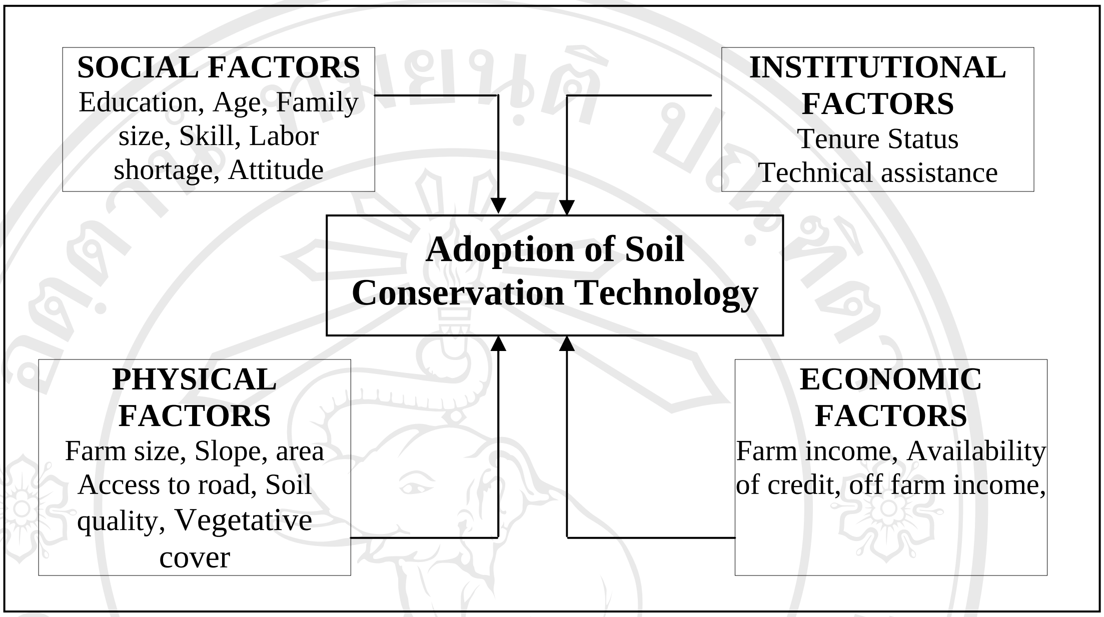

Figure 2.1 Farmer decision-making process on adoption of soil conservation technologies.(Ervin and Ervin, 1982).

The adoption of innovations can be expected to be affect by several factors. Farmers' land management practices are actually influenced by many macro-, meso- and micro- level factors, including availability of resources (natural, human, technological, capital) constraints (biophysical, socioeconomic), and policy environment (including land rights, land tenure, subsidies, taxes, commodity prices, transportation and marketing opportunities) (Rasul, 2003).

Making decision on land management is a complex process that involves several sequential steps, each influenced by various biophysical, personal, socioeconomic and institutional factors. The process starts with farmers perceiving land degradation as a problem, which is influenced by the four major factors mentioned earlier. The decision whether or how to manage land depends on farmers' perception of land degradation as well as on their personal characteristics, socioeconomic condition, institutional support provided and biophysical characteristics of landholdings. These factors also determine the effectiveness and extent of land management practices (Ervin and Ervin, 1982).

2.6.1 Institutional factors

Although the influence of institutional factors on adoption of conservation practices remains a relatively unexplored area of research, there is considerable interest in the "supply" side of the adoption model. Extrapolation of results from studies of adoption in other areas suggests that the market approach, in which emphasis is placed on information, technical and financial assistance, and target clienteles, might achieve greater application of conservation practices. Brown (1981, cited in Feder *et al*, 1985) refers to this as the "Market and Infrastructure Perspective," explaining that "individual behavior does not represent free much as choices within a constraint set and (that) it is government and private institutions which establish and control the constraints." He has proposed three stages in the diffusion process as (1) establishment of diffusion agencies through which the innovation is distributed to the population at large, (2) implementation of an agency strategy to induce adoption, and (3) adoption of the innovation. The availability of credit, limited access to information, aversion to risk, inadequate incentives, farm tenure arrangement, insufficient investment in human capital, inadequate farm size, absence of equipment to relieve labor shortages, unreliable and insufficient supply of complementary inputs, and inappropriate transport infrastructure affects on adoption.(Feder *et al*, 1985).

When a significant cash investment is needed for the use of a new technology, then credit plays an important role in its adoption, particularly for small farmers without readily available cash. The availability of credit should have a direct bearing on the decision to adopt. (Sheikh *et al*, 2003).

The tenure status of the farmer normally plays a significant role in the adoption of soil conservation technologies and was expected to been positively related. If the farmer is leased, the farmer is less likely to make conservation expenditures than when the farmer is the owner. Therefore, farmers with insecure tenure may not adopt soil conservation technologies due to uncertainty about capturing the long-term benefits (Garcia, 2001).

Some studies associating farm tenure (owning or renting) to use of conservation practices show that ownership is significantly related to use of profitable practices but not to use of unprofitable practices (Pampel and van, 1977, cited in Ervin 1985). Even when practices are not controlled for profitability, the relationship of farm ownership and use of conservation practices has been found to be in a positive direction (Abdalla and Kelsey, 1981; Carlson *et al.*, 1993). Ervin (1985) maintains, "Despite past and present investigators' efforts, the question of whether rented land receives less, the same or more erosion control than owner-operated land remains an enigma. Nonetheless, theory and empirical evidence suggest that erosion control decisions on rented land will differ markedly from similar owner-operator decisions."

If a farmer takes advantage of technical assistance opportunities offered to him takes part in community institutions, he is likely to use the no tillage technologies (Jamnick and Klindt, 1985). The technical know-how about an innovation and the benefits associated with its use affect the adoption decision. (Sheikh *et al*, 2003). Studies by Ervin and Ervin (1982) and Norris and Batie (1987) suggest that farmer awareness of a soil erosion problem is the first step in the adoption process and thus is positively correlated with farmers' adoption decisions. A similar result has also been reported from the Central Highlands of Ethiopia (Shiferaw and Holden, 1998).

Several studies indicated the importance of subsidy. It is suggested that the government should subsidized soil conservation activities in the counts for the well being of public as well as future generations. Subsidies for soil conservation measures are identified as the most effective market instrument to curb soil erosion problems in Sri Lanka. It's intended the investment on soil conservation is expected to increase the land value because conservation is not only for improves soil but also increase the productivity. Rise in land value is an incentive to the farmers who can invest further on farm improvement (Gunatilake and Abeygunawardana, 1993).

The extension of a subsidy, either from the government or non-government organizations, was seen to provide an incentive to adopt. Moreover, farmers that received any form of subsidy were thought to have initially conformed to the government's conservation requirement or the NGOs development program (Garcia, 2001).

Most empirical research on the relationship between tenure and conservation practices has focused on the adoption of some form of conservation tillage or crop residue management. Several studies support conventional expectations that owner-operators are more likely than renters to adopt conservation tillage; however a second group of studies found no significant relationship between tenure and adoption of conservation tillage (Meredith, 2000). If the tenure of a lease is short and a considerable investment is required to use any new technology, than the chances of its adoption by a tenant would be less as compared with an owner operator. A tenant farmer also may also have a tendency to avoid an unfamiliar technology. The chances of owner operators adopting the 'no-tillage' technologies are expected to be greater as compared with those of tenant farmers (Sheikh *et al*. 2003).

The technical know-how about an innovation and the benefits associated with its use affects the adoption decision. But the results of Ahmad *et al*. (1991) study show that there was no significant effect of extension links on the adoption of semi-dwarf wheat varieties in the northern rain fed areas of Punjab. However, the frequency of a farmer's visits to an extension agent's office for advice and information representing his access is a variable in this study. (Sheikh *et al*. 2003)

2.7.2 Social factors

According to Schultz (1964), farmers' skill and knowledge about soils, plants, animals, and equipment, what he called "productive art", play an important role in the evolution of land use in any area. Hayami and Ruttan (1971), however, find agricultural land use changes significantly influenced by institutions and technology. Institutions not only govern the processes by which scientific and technical knowledge is created, but also facilitate the application of new management practices. These factors relate to an individuals management skills or entrepreneurial ability and include attributes such as the level of education, farming experience, and training's. The synthesis of the adoption process presented by Feder *et al*, (1985) suggests that generally the level and quality of human capital affects the choice of new technologies in agriculture for early adopters and for an efficient use of inputs, it plays a particularly positive role. Ervin and Ervin (1982) found that education has a positive impact on the adoption of soil conservation technology. They also found that older farmers are less likely to use soil conservation practices. Shortle and Miranowaski (1986) found that experience has a positive effect on the adoption of conservation tillage practices in the Four-Mile creek watershed of eastern Iowa.

Education likewise was expected to have a positive effect on adoption since higher levels of education could be associated with greater information on conservation measures and the productivity consequences of erosion, and greater management expertise (Garcia, 2001).

2.6.3 Physical factors

The physical features of farm such as topography soil type; infrastructure (roads and canals) and climate do affect the uptake of new technologies, depending on nature of the technology.

Farm size is regarded as one of the most important determinants of the adoption of new technologies. Its relationship with adoption depends on fixed costs of new technology, risk preferences and constraints on credit availability (Feder *et al*, 1985). As the influence of this factor varies in different areas and over time, the relationship between adoption and farm size may vary. For small farmers, the level of fixed costs of a new technology is a real impediment to adoption. (Shortle and Miranowski, (1986), Jamnick and Klindt (1985), Lee and Stewart (1993) have all used farm size as a factor influencing the adoption of reduced tillage technologies.

Thus, it is hypothesized that the bigger the farm size, the greater the chances of 'no tillage', technologies being adopted (Sheikh *et al*.2003).

The slope of a plot is expected to influence the conservation decision positively for the obvious reason that erosion is more serious on steeper plots than on flat plots. (Bekele, and Lars, 2003, cited in Sheikh *et al*. 2003).

2.6.4 Economic factors

Higher levels of income imply the ability to purchase the new equipment and to bear risk associated with its adoption. A positive relationship between the probability of adoption and the family level of finance should be expected.

When a significant cash investment is needed for the use of a new technology, then credit plays an important role in its adoption, particularly for small farmers without readily available cash (Feder *et al*., 1985).

Farmer's technology choices are based on their subjective awareness of risk and uncertainty (Feder *et al*., 1985) and risk takers are expected to be more likely to try the new conservation technology (Belknap and Saupe, 1988).

2.7 The use of mind mapping in problem identification

Mind maps were developed for different purposes, such as identifying the likely causes of problems, illustrate the participations of the various agencies for aimed purposes, Identify the linkages in social and economical institutions so on. The approach combines brainstorming with use of concept map.

Mind maps were developed to illustrate participant's view of extension (Blumenthal and Jannink, 2000) and find out the several kinds of views on extension agents. The participant's active involvement on the creating the mind map show the different angles of extension.

In a project of evaluating natural resource management, the program elements can be defined through the use of mind maps and the links between the elements are then compared and adjusted Allen (1997).

The mind mapping technique is a hierarchical representation of ideas used to help the farmer participants in outlining the current problems they had with research, and to develop those features they wished to undertaken by research. The two resulting mind maps were built, the current problems with research in the high country and how participants would like to see research in the high country (Allen and Bosch,1996.