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# Household adoption behaviour of improved soil conservation: the case of the North Pare and West Usambara Mountains of Tanzania

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**Abstract**

The mountains in the northeastern part of Tanzania have been experiencing declining soil fertility and severe soil erosion due to increased cultivation and other factors attributed to population pressure. This study gives the main results of an analysis of household adoption behaviour towards the use of improved soil conservation measures. An interdisciplinary analytical framework for analyzing household adoption behaviour is presented. The framework links three components of the adoption decision process: the perception of the erosion problem, the decision to use improved conservation measures and the level of investment or effort devoted to soil conservation among adopters. Data collected from a random sample of 300 heads of households was used to estimate logit models of perception of the erosion problem and of adoption of improved conservation measures, and a Poisson regression model of effort devoted to conservation. The results show that participation in promotional activities of soil and water conservation (SWC) programmes influences the adoption decision process at all three stages. Also, ranking of soil erosion as the priority problem in agricultural production, participation in labour-sharing groups and having off-farm income influence the willingness and ability to use improved soil conservation technologies and the level of soil conservation effort. 

*Keywords:* Soil erosion; Adoption; Soil conservation; Tanzania; Promotional activities

## Introduction

Land degradation caused by soil erosion and other processes, such as leaching and salinity is a serious environmental threat that has drawn a lot of attention from the international community. It leads to deterioration of soil quality and hence reduces soil productivity. This poses danger to sustainable agriculture, stability and quality of the environment and causes adverse impacts on economic and social development. Politicians and economists around the world not only recognize these dangers but also have initiated efforts to develop effective solutions. These include the development of sustainable land use practices and soil management procedures capable of reducing different forms of land degradation (WCED, 1987; Lal, 1994; Lal and Singh, 1995).

In Sub-Saharan Africa (SSA), agriculture contributes the largest share to social and economic development. In these countries land degradation is a serious problem threatening the agricultural sector. Oldeman (1992) reported that 14 million hectares of agricultural land in SSA are affected by physical degradation and 62 million hectares are subjected to chemical degradation. The land area prone to accelerated water erosion is estimated to be 227 million hectares (Lal and Singh, 1995). Therefore, in order to achieve sustainable social and economic development, land degradation in SSA should be minimized to ensure sustainable land productivity.

Many parts of Tanzania have been experiencing severe soil erosion. Factors such as population growth, deforestation and poor farming techniques have been cited as the main causes of the erosion problem (MTNRE, 1994). Land degradation caused by soil erosion has been a major threat to agricultural development. It reduces yield directly via poor seedling establishment, water logging and crop burial. Indirectly, erosion affects crops through loss of nutrients (nitrogen, phosphorous and potassium) and organic matter, moisture deficiency and general deterioration of the structure of the soil, as well as reducing the efficiency of other inputs (Lal, 1985).

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Yield loss is not the only on-site effect of erosion, but there are also other damages. These include: higher fertilizer application rates, and accumulation of stones at the field which have to be collected, thus increasing production costs (Lutz et al., 1994; Aune and Lal, 1995). Erosion also leads to damage to the environment surrounding the erosion site. Off-site effects include water pollution, sedimentation and siltation of rivers and lakes and disruption of aquatic ecology. Siltation of lakes, rivers and dams has in some cases reduced hydroelectric power generation. Finally, erosion produces externalities to future generations by reducing the capacity for agricultural production (Pimental et al., 1995).

The rate of soil loss in selected areas of the country increased from 1.4 tons/ha/year in 1960 to 105 tons/ha/year in 1965 to 224 tons/ha/year in 1980 (MTNRE, 1994). It has been established that population growth has resulted in increased human activities and land demand. These have triggered overgrazing, deforestation and use of inappropriate farming methods, thus causing soil erosion. Population increased from 21 million in 1984 to 28 million in 1994 (TBS, 1990). It has been estimated that between 300,000 and 400,000 ha of forest are cleared every year to meet the increased demand for farmland, timber and firewood (Bagachwa and Mbele, 1994) while tree regeneration and replacement is only 25,000 ha per year (Mayawalla, 1994).

The northeastern mountains in Tanzania are endowed with enormous natural resources and favourable climatic conditions offering opportunities for development. In the beginning of the 18th century most of the northeastern mountains of Tanzania were covered with natural forests. The major part of arable land was uncultivated, covered with natural vegetation. Land was owned by clans and the clan chief was responsible for allocating land to clan members. Once allocated to the household, land became an inheritable property. Shifting cultivation and fallow practices were used to maintain soil fertility. Farmers cultivated the virgin land for two years and opened up new land to allow soil regeneration (Ruthenberg, 1964; Ngatunga, 1981; Scheinmann, 1986).

In the 1920s the population started to increase at a very fast rate. As the population increased, more land was put into cultivation. By 1936 all arable land was under cultivation. At this point pressure on land became severe, leading to land scarcity. Also, soil conservation practices (shifting and fallow cultivation) could not be applied anymore.

Land alienation by the German and British colonial governments also contributed to land pressure. In the 1950s considerable areas of land were taken by the European settlers for establishing coffee and tea plantations in the Kilimanjaro and Usambara mountains, respectively. In addition, more land was alienated as forest reserves, thereby squeezing people into a smaller land area.

In response to increased land scarcity at high altitudes farmers acquired lands in the low lands for cultivation of annual food crops, mainly maize, beans and rice. Also, in trying to meet their land needs, farmers resorted to cultivation of very steep slopes and encroachment of forests, valley bottoms and wetlands, which play a key role in the protection of the environment. People started to clear parts of natural forests for crop production, livestock grazing, settlement and firewood (FAO, 1971). As a result of these practices, most of the soil cover was removed, rivers and springs dried up and land productivity started to decrease due to soil degradation. However, Ezaza (1992) observed that land scarcity attributed to population pressure is not the only cause of natural resource degradation in the northeastern mountains. Socio-economic factors such as traditional values and economic policies have also contributed to influencing people's perception and behaviour towards resource utilization. Introduction of a poll-tax, for example, led to increased cash needs. This together with the introduction of smallholder cash crops (coffee and tea) triggered the demand for land to cultivate tea and coffee in order to meet the increased demand for cash (Ezaza, 1992).

Together with expanding agricultural land, farmers adopted various land management and soil conservation practices aimed at improving soil productivity. Such practices include mulching, crop rotations, intercropping and minimum tillage. Also, farmers started to transport manure from livestock barns to food and cash crop fields near the homesteads and the valley bottoms. Irrigation structures such as furrows were developed to transfer water from the rivers and streams to fields during the dry seasons. At the same time an intensive cultivation system was developed to improve the productivity of the coffee/banana homegardens. In addition to farmers' efforts the colonial government initiated various activities aimed at reversing the soil degradation problem in the mountain areas. These included research programmes on soil loss; advisory services and introduction of physical measures for reducing soil erosion. In the 1930s several conservation trials were conducted in the northeastern mountains. Demonstration plots were also initiated to make farmers aware of the use of soil conservation measures to maintain soil fertility.

In 1947 the British colonial government introduced several soil conservation techniques in different areas under the Land Usage Schemes. The schemes were enforced in the Usambara and Pare mountains between 1946 and 1958. The objectives of these schemes were: (1) to develop an agricultural production system which would rehabilitate eroded areas and (2) to generate information and experience on soil conservation. The focus was on controlling land degradation and ensuring that land could be cultivated without damaging the soil. The main activity was to reduce soil erosion in order to improve crop yield. Activities related to Land Usage Schemes included construction of bench terraces and tie-ridges, contour cropping, demarcation of forest boundaries and tree planting. In addition, new cash crops and on-farm demonstrations of improved agricultural practices were introduced. Together with these activities laws were passed for the local authority (chiefs) to put into effect. The laws prohibited cultivation on slopes over a certain degree of steepness; required mandatory tree planting on hill crests and prohibited cultivation of land near the streams and grass burning. Each household was required to construct terraces and 10-yard wide contour strips of permanent crops in at least half an acre in fields at slopes exceeding 25% and slopes under 25%, respectively. Agricultural staffs were mobilized to enforce these laws. The chiefs and extension personnel turned police, forcing people to implement Land Usage Schemes activities and laws. A large number of people were prosecuted by chiefdom courts for not implementing conservation measures or breaking laws. As a result, Land Usage Schemes as well as extension personnel became unpopular among people. This led to passive resistance against the schemes and in some areas protest meetings and riots occurred. In 1955 the scheme collapsed (Kimambo, 1991).

After independence in 1961, there was very little mentioning of the soil conservation measures. The colonial soil conservation laws received no emphasis and people started to cultivate in formerly prohibited areas like on very steep slopes and in forest reserves. In 1963 the district authority in the west Usambara mountains for example, allocated 36,000 ha of the Shume Forest Reserve to farmers for cultivation to ease the land scarcity problem. Agricultural development programmes did not include soil conservation as a major theme either. Research efforts on soil conservation received minimum attention and emphasis was put on the introduction of technologies with short-term returns such as new crop varieties and chemical fertilizers among other things.

By 1970 destruction of natural resources in the northeastern mountains became severe. In the Usambara and Pare mountains major areas of forests were cleared for agricultural production. Some of the natural forests and woodlands were turned into grazing areas. Continuous cultivation on the gentle and steep slopes made the soil loose and bare with little cover. These conditions accelerated soil erosion by water, even from low intensity rainfall (Shelunkindo and Gaudens, 1993; Shenkalwa, 1989; Kimambo, 1991; Aune, 1994; Shelukindo, 1995).

The relationships between population pressure, increased cultivation, environmental destruction, erosion and food shortage are depicted in Fig. 1.

As argued above, the northeastern mountains have a long history of efforts to reverse soil degradation through soil conservation. The conservation methods applied to date include those that have emerged from farmers' reactions to the consequences of land

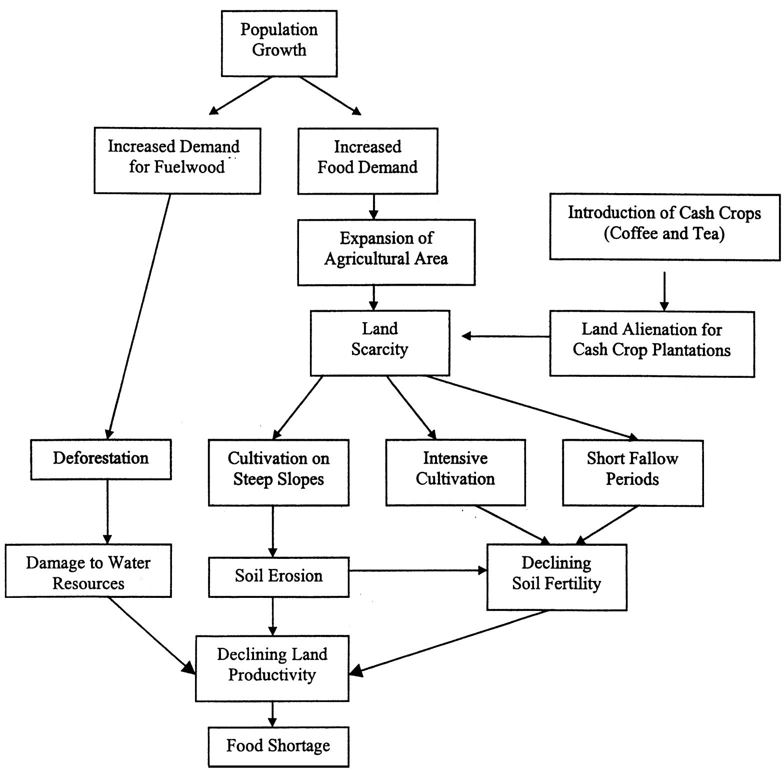


Fig. 1. Land degradation in the northeastern mountains.

degradation (traditional methods);[1] those that were introduced during colonial rule (see above) and those that have resulted from external technological intervention such as soil and water conservation (SWC) programmes initiated by the government and development institutions. These interventions include the introduction of substantially improved soil conservation technologies intended to supplement traditional conservation methods which have been proved to be ineffective in circumventing soil degradation. In particular, at the present level of erosion the traditional methods are considered insufficient to reduce erosion or its impacts. (Glückert, 1994; Shelunkindo and Gaudens, 1993). The improved soil conservation technologies introduced in the study area consist of measures such as soil erosion control, water harvesting techniques, afforestation and irrigation. They cannot only halt erosion but also (gradually) restore topsoils.

In 1979/80, the Government of Tanzania, in collaboration with the Regional Integrated Rural Development Programme supported by the technical aid programme of Germany (GTZ), initiated an integrated Soil Erosion Control and Agroforestry Programme (SECAP) to promote soil erosion control throughout the west Usambara mountains (Lushoto district). The programme focused on two main aspects: (TWMP, 1976)

- reducing environmental destruction, and
- restoring the ecological balance in the target areas in the west Usambara mountains.

The programme aims at achieving sustainable land use systems by applying improved soil and water conservation measures and agroforestry systems, so as to increase land productivity (Shelunkindo and Gaudens, 1993). In 1992 GTZ started another soil and water conservation programme in the north Pare mountains. This programme is known as the Tanzania Forestry Action Plan (TFAP). The programme focuses on encouraging and assisting farm households to attain sustainable use of natural resources. The main components of soil and water conservation are basically the same as in the SECAP programme and include soil erosion control, soil fertility management, site specific crop and tree management, water management and buffer zone management. Activities carried out involve construction of improved physical soil erosion control measures (bench terraces, *fanya juu*[2] terraces, infiltration ditches and cut-off drains), improved agroforestry, afforestation of catchment areas, protection of river banks, use of manure and promotion of biological measures for improving soil fertility.

In order to promote adoption of improved SWC technologies, the GTZ programmes provide various forms of support to farmers. To reduce labour constraints they have revived the traditional labour sharing groups (known as kiwili and vikwa) in the west Usambara and north Pare mountains. The programme has also assisted people in forming village-level land use planning committees responsible for planning and overseeing the implementation of SWC activities including afforestation. It also provides farm inputs such as improved seed varieties and implements for the construction of SWC structures at subsidized prices. Furthermore, villagers are assisted in establishing tree nurseries to promote agroforestry and afforestation. They receive technical assistance required for laying out physical SWC structures from village-based TFAP facilitators. To enhance awareness of the soil degradation problem and soil conservation, the programmes carry out field tours and training on soil conservation methods. Technical information is provided through extension services, video shows, leaflets and pamphlets.

In 1989, the Netherlands Government under the Dutch Volunteer Service (SNV) initiated an irrigation programme (TIP) in both the west Usambara and north Pare mountains. The objective of this project was to improve irrigation structures and improve access to irrigation water. The project was aimed at rehabilitating and improving furrow irrigation systems to increase water availability and utilization for irrigation. The main activity was the improvement of water reservoirs. The project organized farmers into water-user groups and provided materials and technical support required for the construction of the irrigation systems. In collaboration with the SECAP/TFAP programmes TIP encouraged construction of terraces in fields located on slopes as a precondition for utilizing the improved irrigation system. TIP also carried out promotional activities, such as farmer training and extension services.

Household participation in activities organized by these programmes depended on nomination or self-selection. In most cases nomination of heads of households to participate in soil conservation promotional activities or events such as training and village tours, was based on criteria such as position in village committees (for example, village leader), membership of village land use planning committees or previous use of soil conservation measures.

Just and Zilberman (1985) and Ellis (1988) observe that in developing countries the introduction of many new technologies has met with only partial success as measured by observed rates of adoption. They argue that this is due to constraints such as lack of credit, limited access

[1] The traditional soil and water conservation methods refer to practices built upon farmers' indigenous knowledge and experience. They include intensive cultivation, zero-grazing, agroforestry, forestry (woodlot), furrow irrigation, trash lines, grass strips, minimum tillage, and biological or agronomic methods such as cereal-legume intercropping, rotation and mulching.

[2] Fanyajuu ("through up hill") is a terracing process whereby a trench is excavated to form an embarkment on the upper side by throwing the excavated soil uphill.

to information, risk aversion and labour and capital shortages. Though many development projects have attempted to remove some of these constraints, success has been only partial. Some innovations have been adopted by only a very small group of farmers while some of them are partially adopted or abandoned after some time. Ervin and Ervin (1982) observe that unsustainable adoption of soil conservation measures is due to a lack of understanding of the factors that influence farmers' adoption behaviour.

Hence, in order to develop soil conservation strategies that will enhance sustainability of agricultural production systems in the northeastern mountains, the improved soil conservation technologies introduced through SWC programmes need to be assessed not only in terms of their technical performance, but also in terms of their acceptability by land users. The latter is the main purpose of this study. It intends to assess household adoption behaviour by integrating economic and sociological factors which influence household's decisions on investment in improved soil conservation technologies. Such an assessment will provide a useful guide for designing appropriate and sustainable soil conservation programmes and support services for the study areas and similar areas. For that purpose we develop an adoption model with three stages. The first models a household's attitude towards and perception of the soil erosion problem; the second the household's decision on adoption and the third the household's level of investment in improved conservation measures. Factors influencing each stage of the adoption process are identified and analyzed. Since no data sources were available to estimate the above-mentioned model, a household survey was organized.

As observed by Lockeretz (1990), despite considerable effort there is still very little known about who conserves the soil. Erenstein (1999) argues that the advances so far are still patchy. This implies that this paper is not only relevant to soil conservation in Tanzania but that it may also contribute to a better understanding of soil conservation in general, notably in mountainous areas in Africa, Asia and Latin-America.

This paper is organized into five sections. In the first section, some theoretical notions of adoption behaviour are presented followed by the empirical model in the next section. In the third section, the estimation results are discussed. Finally conclusions of the study and implications of the results for SWC programmes and institutional support to soil conservation in the study area are presented.

## Theoretical notions

The history of research on soil conservation adoption indicates that there has been a gradual expansion of focus over time. Earlier research consisted of either sociological or economic adoption–diffusion models. Recent studies have integrated economic and sociological models together with institutional and physical aspects to explain differences in adoption behaviour among individual households (Ervin and Ervin, 1982; Nowak and Korsching, 1987; Hansen et al., 1987; Lynne et al., 1988; Gould et al., 1989; Boahene, 1995; Boahene et al., 1999).

In this study we start from a comprehensive interdisciplinary theoretical framework which combines a sociological and an economic model of innovation adoption behaviour. The reason why this framework is chosen is that economic adoption models based on utility or profit maximization fail to encompass attitudinal and social variables which are also important in explaining the household adoption decision-making process. Utility or profit maximization theory does not take into account social processes and structures that co-determine households' resource allocation preferences and behaviour. Likewise, the innovation–adoption–diffusion models used in sociological studies downplay economic variables. As is well-known, omission of important explanatory variables (sociological variables in economic models or economic variables in sociological models) that are correlated with variables included in the models leads to biased estimators. Moreover, inference procedures are invalidated (Greene, 1997). In order to handle these problems, the framework for assessing household decision-making behaviour needs to be improved by combining both sociological aspects such as social networks, attitudes, beliefs, perceptions and intentions and economic factors, such as profit, income and access to credit. Our interest is to model household's conservation decisions by merging profit/utility maximization theory with sociological decision theory.

The sociological theories of adoption of innovations are rooted in Rogers and Shoemaker's (1971) model. This model is based on the assumption that an individual goes through four adoption stages: awareness, evaluation, trial and adoption. Access to on-farm and off-farm information is the important determinant in this model. Educational programmes, extension services, social interactions with neighbours and friends have been identified as the key sources of information. Individual characteristics such as age, sex and education also influence the time it takes for an individual to complete the entire adoption process.

An extension of the decision model is the adoption curve model which classifies adopters into various categories namely innovators, early adopters, early majority, late majority and laggards (Rogers and Shoemaker, 1971). This model has made a great contribution to the research on innovation adoption. Economists (for example, Besley and Case, 1993) and sociologists (e.g. Korsching and Nowak, 1983) have used it to develop analytical frameworks and to study household characteristics and socio-economic factors that influence adoption behaviour.

Sociological theories also capture the role of community actions and peer groups in the adoption process. Group dynamics theory emphasizes the interactions between individuals and others in society which translates into joint and individual decisions on technology adoption. The theory demonstrates the complex nature of the decision-making process and the implications for adoption behaviour.

The economic theories used for explaining adoption of innovations are rooted in utility or profit maximization theory (Griliches, 1957). Utility is explained in terms of the return or profit that accrues from farm production or leisure derived from avoiding work. Furthermore, the theory indicates that households obtain different levels of profit from different technologies, implying that the choice of production technology is influenced by profit prospects (Doll and Orazem, 1984). Attitudes towards risk and uncertainty are identified as the most important personal characteristics that shape farm households' rational production actions related to technology choice and resource allocation.

Major distinctions among economic models relate to the level of aggregation (individual or farm household adoption versus aggregate adoption), and to the treatment of time (dichotomous choice versus continuous adoption). Distinctions are also made between divisible and lump technologies. Models dealing with aggregate adoption are concerned with the number of farmers adopting a single innovation or a package, the area under new practice and how the innovation spreads through a geographical area over time. In some cases aggregate adoption takes into consideration the dynamic adoption pattern among different groups in the population based on the adoption curve model. Individual farm-level adoption models assess adoption in terms of the likelihood that farmers with given characteristics will adopt a given technology. They frequently use the dichotomous approach describing adoption as whether or not a farmer adopts a complete package or a few components. In relatively few cases continuous models have been applied to explain individual farm level adoption processes. Dynamic models assess adoption decision-making over time, taking into consideration changes that influence a household's perceived performance of the technology. These relate to the level of information about the technology the household accumulates over time as a result of learning-by-doing (experience with a technology), and to risk attitude and prices. (For further details on sociological and economic adoption theories see Semgalawa, 1998 and the references therein.)

This study focuses on individual heads of households. The reason to consider the head of household as the unit of analysis is that this person is the ultimate decision maker with respect to adoption. It should be observed that the notions: households, farmers and heads of households will be used as synonyms.

We consider household decision making as a process involving three stages: (1) perception of the erosion problem explained by the household's knowledge and attitude towards erosion, (2) adoption i.e. whether or not a household uses improved soil and water conservation measures and (3) effort devoted to soil conservation. The latter is defined here as the number of improved physical measures the household has installed. Modeling of the adoption decision process in three stages allows us to analyse the decision steps separately to ensure a thorough understanding of the nature of household's soil conservation behaviour.

The sequential process with three stages is based on the assumption that for a household to reach each of the stages, it goes through a mental decision process. We assume that a household's decision to adopt improved conservation technologies is co-determined by its perception of the soil erosion problem shaped by economic and socio-cultural variables. Similarly, adoption is a prerequisite for effort devoted to conservation. The integrated sociological-economic model of adoption is presented in Fig. 2.[3]

The theoretical model outlined above is tested on a data set collected via a survey. For this purpose a sample has been drawn from the population of farmers in the North Pare and West Usambara Mountains. The questionnaire used in the survey has been designed in such a way that it reflects the theoretical model outlined above. In particular, the sequential three-stage household decision making model has been explicitly incorporated. Moreover, the integrated sociological-economic model of adoption has determined the set of explanatory variables on which information has been collected via the survey. The link between the theoretical model and the questionnaire is the empirical model which will be discussed in the next section.

The following observations apply. First, the present case study fits into a wider literature on the socio-economic aspects of soil erosion and the explanation of differential adoption rates of soil conservation. Thampapillai and Anderson (1994) present an overview of the main socio-economic concepts relevant to the analysis of soil degradation problems in developed and developing countries. Grepperund (1997) reviews the evidence on how farm decisions may affect soil degradation processes. He furthermore develops a classification scheme

[3] In the 1980s USA researchers began to use comprehensive approaches which integrate sociological and economic models to study adoption of soil conservation practices e.g., Ervin and Ervin (1982), Bultena and Hoiberg (1983), Jamnick and Klindt (1985), Ashby (1985), Nowak (1987) and Lynne et al. (1988). These approaches have also been applied in some developing countries such as Ghana and Dominican Republic by Boahene (1995) and Hansen et al. (1987), respectively.

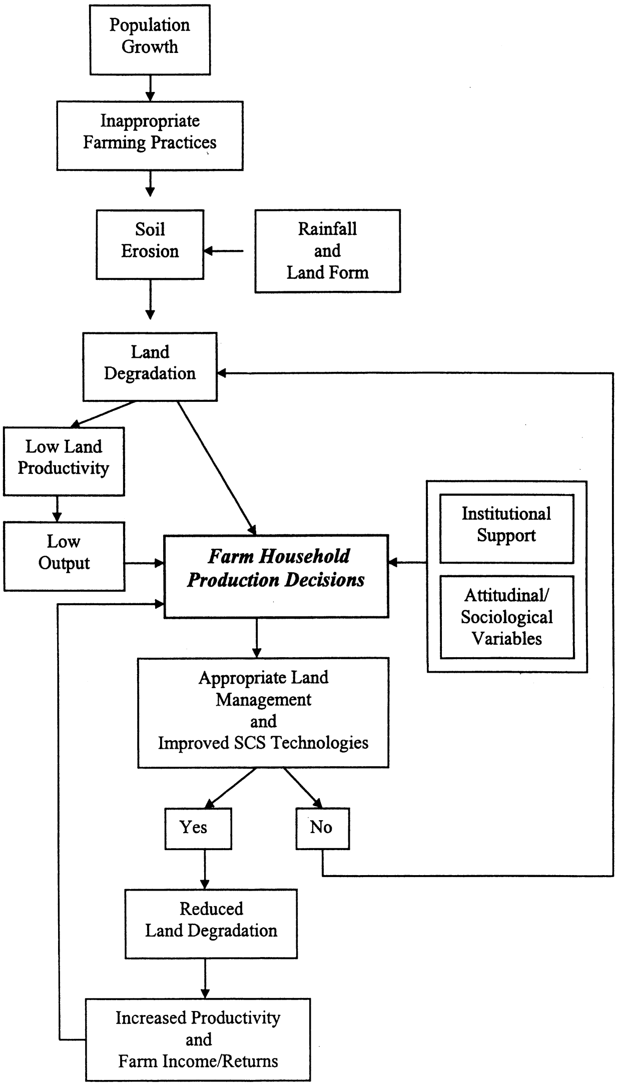


Fig. 2. The socio-economic decision model.

of agricultural investment decisions and reviews the literature in terms of how various decisions differ with respect to their impacts on current output and long-term soil fertility. He also discusses common characteristics of theoretical dynamic models of soil conservation. Erenstein (1999) reviews the adoption literature with respect to soil conservation. His main findings are that the advances so far are patchy; that the research problems are very complex and that uni-causal models generally founder (Blaikie and Brookfield, 1987). Moreover, most adoption models have not explained farmers' behaviour well or are not very useful (Miranowski and Cochram, 1993; Cambino and Napier, 1994).

Secondly, research on soil erosion and soil conservation in Eastern Africa and Tanzania in particular is very scarce indeed. Nkonya et al. (1995) investigated factors affecting adoption in Northern Tanzania whereas Shelunkindo and Gaudens (1993) analyzed development and experience of soil erosion control in the West Usambra mountains. Sianga (1994) and Shenkalwa (1989) evaluated erosion control in physical terms.

The upshot of the above is that despite considerable effort there still is very little known about adoption of soil conservation measures in general (Lockeretz, 1990) and in Tanzania in particular. Moreover, Erenstein (1999) argues that soil conservation is extremely socio-economic site-specific. This warrants the present study, in particular because of its emphasis on the integrated socio-economic approach to the three-stage household decision process which, to the best of our knowledge, is unique in this area. Moreover, it pays special attention to the role of promotional activities, which is important from a policy point of view.

## The empirical models

The empirical models also come down to the integration of economic and sociological models. This calls for the inclusion of both economic and sociological explanatory variables into the models. Most of the socio-economic empirical studies on adoption of soil conservation have focused on the following categories of variables that influence a farmer's decision to adopt: farm/physical factors such as ownership, location and land form; demographic characteristics such as age and education; sociological factors such as social status, attitudes, beliefs towards land degradation and soil conservation and institutional factors like extension services and participation in soil conservation programmes; economic/financial factors such as farm income, indebtedness, investment costs, availibility of labour and risk. (see also Featherstone and Goodwin, 1993; Mshana, 1992).

A description of the explanatory variables and of the hypothesized direction of the relationship between each variable and the dependent variables (perception, adoption and effort) is presented in Table 1. A brief discussion of how the dependent variables and some of the independent variables were developed or constructed is presented below.

### *The dependent variables*

The dependent variable for the perception model is PERCEPRO, indicating whether or not a household perceives the soil erosion problem. PERCEPRO was measured by means of two questions. One related to the knowledge of the occurrence of soil erosion in general (EROEK) and the other to the causes of it (EROCAUSE). Households with score "1" on both variables were assigned a "1" and a "0" otherwise for PERCEPRO.

The dependent variable for the adoption model, ADOPTION, indicates whether or not a household uses improved soil conservation measures. Improved

Table 1
Variables included in the empirical models and hypothesized direction of influence[a,b]

| Independent variable | Description | Measurement | Hypothesized direction of influence on: | | |
|---|---|---|---|---|---|
| | | | Perception | Adoption | Effort |
| AGE | Age | Years | – | – | – |
| EDUC | Education level | Years | + | + | + |
| HSEX | Gender | Female/male: 0/1 | + | + | + |
| MAST | Martial status | Married/single: 0/1 | – | – | – |
| ETHN | Ethnic group | Immigrant/native: 0/1 | + | + | + |
| WEALTH | Wealth category | High/Average/Low | + | + | + |
| CONTUDE | Attitude towards conservation | Negative/positive: 0/1 | + | + | + |
| BENTUDE | Attitude towards future benefit | Negative/positive: 0/1 | ~ | + | + |
| EROEX[c] | Knowledge of soil erosion in general | No/Yes: 0/1 | ~ | ~ | ~ |
| EROCAUSE[c] | Knowledge of causes of soil erosion | No/Yes: 0/1 | ~ | ~ | ~ |
| EROKNO | Knowledge of erosion on own land | No/Yes: 0/1 | ~ | + | + |
| ERORANK | Ranking soil erosion as priority problem | No/Yes: 0/1 | + | + | + |
| PRODTRE | Perception of production trend | Increase/decline: 0/1 | + | + | + |
| SOST | Social obligations | No. of obligations | + | + | + |
| PERCEPRO | Perception of soil erosion problem | yes/no: 1/0 | ~ | + | + |
| INCOME | Annual farm income | ‘0000 T. shillings | ~ | + | + |
| LABOUR | Family labour | Full-time adults equivalents | ~ | + | + |
| HELP | Other sources of labour | No/yes: 0/1 | ~ | ~ | + |
| RISK | Risk attitude | Low/large: 0/1 | ~ | + | + |
| FASZ | Farm size | Acres | ~ | + | + |
| OFINC | Off-farm of income | No/yes: 0/1 | ~ | ± | ± |
| REMIT | Financial support from relatives | No/yes: 0/1 | ~ | + | + |
| CASHCRO | Cash crop | No/yes: 0/1 | ~ | + | + |
| CONPROG | Participation in conservation programmes | No/yes: 0/1 | + | + | + |
| EXVIST | Visits by extension staff per year | Number | + | + | + |
| LABSHA | Participation in labour-sharing groups | No/yes: 0/1 | ~ | + | + |
| INFSO | Level of access to information | Number of sources | + | + | + |
| DIST | District where household is located | Mwanga/Lushoto: 0/1 | + | + | + |
| EROPOT | Erosion potential based on location of plot | Low/medium/High | + | + | + |

[a] ~ : Factor not included in the respective model; ± : Direction of influence is indeterminate; + : positive influence; – : negative influence.
[b]The variables relate to the head of household, unless stated otherwise.
[c]These variables are combined to form the perception variable.

technologies include *fanya juu,* bench terraces, infiltration ditches and macrocontour lines. Traditional technologies are grass strips, trash lines, agroforestry, zero-gazing and minimum tillage. A “1” was assigned to households using at least one of the improved soil conservation technologies (adopters) and a “0” to households either using traditional measures only or no conservation methods at all (non-adopters). It should be observed that three rather than two categories of adopters could have been distinguished: non-adopters, adopters of traditional methods and adopters of improved techniques. However, in the preceding section we observed that traditional methods cannot halt erosion nor reduce its impacts. Moreover, virtually every farmer used at least some traditional method. Therefore, adopters of traditional methods have been merged with “true” non-adopters.

The dependent variable of the effort model, EFFORT, stands for the intensity of soil conservation. Obvious indicators of intensity are the proportion of area under conservation or expenditures on conservation. However, the pilot study revealed that no reliable information on such variables could be obtained from the respondents. Therefore, it was decided to measure EFFORT as the number of improved physical conservation measures used. We assume that the more conservation measures are used, the more the household invests and the more resources (labour and capital) are used.

*The independent variables*

Since the meaning, measurement and hypothesized direction of influence for most of the independent variables included in the three models are fairly clear, only a few of them are discussed here.

Before going into detail we observe that according to economic innovation models the adoption decision depends on the expected net benefits from adopting new conservation technologies. However, the respondents interviewed during the pilot study were unable to provide reliable information on this variable. Therefore, this variable was not explicitly considered. The following procedure was adopted to take net benefits implicitly into account. First, expected benefits were assumed to be positively correlated with the perception variable defined above. Secondly, the costs of adoption per unit were assumed to be constant over the farmers. This seems like a reasonable assumption for such variables as labour. However, a disturbing factor is the distance from the village, in particular uphill: the longer the distance or the further uphill, the larger the adoption costs. However, the distribution of the plots of land of the farmers in the sample and in the population is such that every farmer owns plots at various distances from the village, also uphill. In particular, every farmer owns a plot of land in a narrow margin around the minimum distance from the village.[4] Those farmers who, on the basis of the above expect net benefits, are assumed to adopt soil conservation measures. Determinants of the expected net benefits are discussed below.

The variable education (EDUC) is included as a proxy for the capacity of the head of household to understand technical aspects related to soil erosion and conservation. Higher education levels are hypothesized to be associated with more access to information on the erosion problem and improved conservation measures. Hence a positive relationship with perception, adoption and effort is assumed. Age of the head of household (AGE) is hypothesized to have a negative influence on perception, adoption and investment level. Because they are less equipped and less motivated, older heads of households tend to be less knowledgeable about the causes and occurrence of soil erosion and its impact on productivity. In addition to this, older heads of households are expected to have shorter planning horizons than younger ones. Given the fact that benefits from soil conservation are not realized within a short time period, older heads of households are more likely to refrain from making conservation investments. The variable ETHN (ethnic group) refers to whether or not the household is native. Natives are those heads of households whose ancestors were original inhabitants of the area. It is hypothesized that immigrants are less likely to adopt soil conservation measures and are expected to make lower conservation investments compared to native households because of cultural differences. With respect to the variable WEALTH three categories were established: high, average and low. The assumption is that wealth has a positive impact on all three dependent variables. This is because the higher level of resources enables a farmer to acquire more information on soil erosion, and on improved soil conservation technologies and to invest more.

[4] It should be observed that under these conditions the definition of ADOPTION as a binary variable is preferable to a definition such as the proportion of land under conservation. The latter would be influenced by the costs related to distance whereas for the binary variable the costs may be assumed to be constant over farmers.

The conservation attitude variable, CONTUDE, refers to whether or not the head of household agrees that he has responsibility to protect the soil quality for future generations. The hypothesized positive direction of influence on the three dependent variables is based on the assumption that heads of households who believe that they have the responsibility to protect the soil quality are likely to be more aware of erosion and consequently are in a position to perceive the erosion problem. They are also assumed to see the need to control for erosion (use improved soil conservation technologies) and to form favourable attitudes towards investment in effective conservation technologies. The variable BENTUDE is a proxy for a household's willingness to invest in improved soil conservation technologies despite the fact that benefits are not being realized within a short period. This variable is hypothesized to have no influence on the perception of the erosion problem, and a positive influence on both adoption and effort. It is expected that households with a positive attitude towards future benefits are likely to use improved conservation measures and put more effort into soil conservation than households with a negative attitude towards future benefits. The variable social status (SOST) captures the household's level of interaction and social links within society. The indicator used for this variable is the number of formal and informal obligations the head of household has in society. It is assumed that heads of household with a lot of obligations in society possess a higher social status. This gives them more opportunities than others to interact with development agents, extension agents and people in other villages and areas. Therefore, heads of households with a higher social status are likely to have more access to reliable information on soil conservation and hence a better knowledge of soil erosion and conservation than others. Knowledge, together with the aspiration to maintain their distinctiveness, makes heads of households with a higher social status tend to be more innovative than heads of households with a lower social status. It is therefore hypothesized that the number of social obligations will be positively related to perception, adoption and effort.

Perception of the soil erosion problem is an explanatory variable in both the adoption and effort model. In this way the sequential decision-making process is captured. Positive relationships are hypothesized (Fig. 3).

The variable INCOME refers to a household's annual net farm income. This is the income obtained from crops and livestock sales less variable costs. A positive relationship is expected between farm income and adoption as well as the level of investment. The variable RISK indicates the household's attitude towards risk. It was measured by confronting the respondent with two hypothetical investment decisions. One decision involved low risk and low profits; the other large risk and large profits. A positive direction of influence is hypothesized

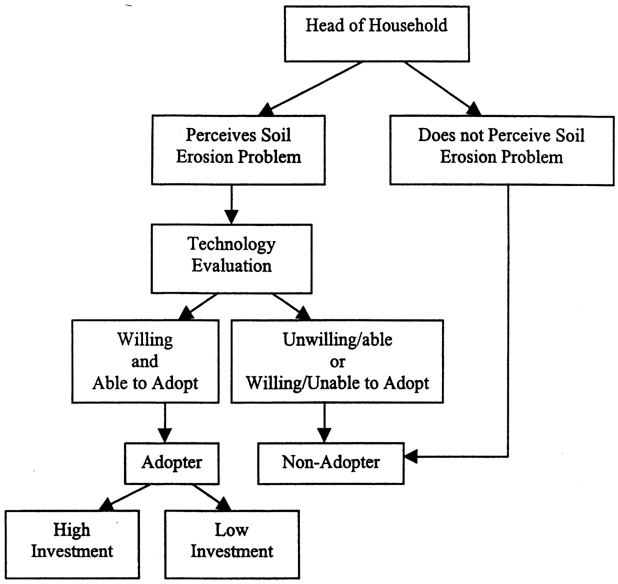


Fig. 3. The relationship between perception, adoption and effort.

for adoption and effort: those who opt for the latter decision (large risk) are more likely to adopt improved conservation measures and devote a higher level of resources to conservation. The variable OFINC represents income earned from non-farm activities, mainly off-farm employment and businesses such as small shops, known as *duka*. The direction of influence for this variable on adoption and effort is indeterminate. We expect a positive influence on the assumption that off-farm income would increase household's ability to use hired labour for conservation activities. On the other hand, if farming is not the main income earning activity, off-farm income earners may decide not to invest their financial resources in soil conservation. In other words, households with off-farm income may be less concerned about farming profits since they do not make their total living from the land. Also, such households are likely to face labour shortage due to competition between farming and off-farm activities which reduces their ability to install physical soil conservation structures.

The variable participation in soil conservation programmes (CONPROG) indicates whether or not the head of household participated in promotional activities provided by soil conservation programmes. These include educational and awareness enhancing activities such as training on soil conservation measures, video shows, village tours, farmers' field days and support services such as cost-sharing, input subsidies and technical assistance. It is hypothesized that, heads of household who participated in SWC promotional or awareness enhancing activities and/or received support from the programmes are likely to perceive the soil erosion problem, adopt improved conservation measures and devote more effort to conservation.

The variable DIST is included as an indicator for the difference in number of years the SWC programmes have been operating in the two areas. This is a proxy for level of exposure to and experience with improved soil conservation activities. A positive direction of influence is hypothesized for perception, adoption and effort. This is because, due to longer exposure to soil conservation programmes, households located in the west Usambara mountains are more likely to perceive the soil erosion problem and adopt improved soil conservation measures than households in the north Pare mountains. Adopters of improved soil conservation technologies in the west Usambara mountains are also expected to make higher investments in soil conservation than those in the north Pare mountains, for the same reason.

## Empirical results

Data collection was divided into two phases. The preliminary survey, which included secondary data collection and a pilot or exploratory survey was first carried out. It was followed by the main survey. A total of 24 villages drawn from five representative districts were involved in the preliminary survey. This survey was used for testing the questionnaire, collecting information for refining the focus of the study, developing the conceptual model, guiding the selection of the research sites and designing the ultimate household interviews.

A total of 15 villages in the north Pare and west Usambara mountains representing various altitude zones were selected for the final individual household survey.[5] Only villages that had both adopters and non-adopters were selected. From each village, 20 heads of households were randomly selected, making a total of 300 heads of households. Where necessary, purposive selection was used to ensure that different categories of households, such as female-headed households were included in the sample.

Summary statistics are presented in Appendices I and II. The sample had 162 adopters (54%) and 138 (46%) non-adopters with an average age of 52 and 54 years, respectively. Also 68% of households perceived soil erosion as a problem while 32% did not.

The perception and adoption models are standard logit models. The effort model is a Poisson regression model because of the preponderance of zeros, the small values and clearly discrete nature of the dependent variable. The estimates for the three models are presented in Table 2. Before going into detail we observe that for

[5] The main survey included less villages and districts than the preliminary survey. Nine villages included in the preliminary survey were dropped because they did not meet the criterion that there ought to be sufficient adopters and non-adopters in each village.

Table 2
Estimation results for perception, adoption and effort: marginal effects, standard errors (within brackets) and level of significance

| Variable | Perception | Adoption | Effort[a] |
|---|---|---|---|
| Constant | 0.3886[b] | – 0.6908[b] | 0.0319 |
| | (0.0828) | (0.1272) | (0.0442) |
| Sex of head of household (HSEX) | 0.0976 | — | — |
| | (0.0616) | | |
| Martial status of hh (MAST) | – 0.1777[c] | — | — |
| | (0.0966) | | |
| SWC programme (CONPROG) | 0.0670 | 0.4445[b] | 0.4516[b] |
| | (0.0562) | (0.07058) | (0.1264) |
| District (DIST) | – 0.2536[b] | — | – 0.1974 |
| | (0.0615) | | (0.1442) |
| Cash crop (CASHCRO) | — | 0.1984[b] | — |
| | | (0.08214) | |
| Erosion knowledge (EROKNO) | — | 0.1464 | — |
| | | (0.09016) | |
| Erosion rank (ERORANK) | — | 0.1858[b] | 0.2815[b] |
| | | (0.07040) | (0.1066) |
| Farm size (FASZ) | — | 0.0236[c] | — |
| | | (0.01121) | |
| Labour sharing (LABSHA) | — | 0.1077[c] | 0.1552 |
| | | (0.02018) | (0.1286) |
| Off-farm income (OFINC) | — | – 0.1294 | – 0.2442[c] |
| | | (0.08110) | (0.1239) |
| Extension visits (EXVIST) | — | — | 0.0037 |
| | | | (0.0021) |
| Education level (EDUC) | — | — | 0.2857 |
| | | | (0.2432) |
| Family labour (LABOR) | — | — | 0.0916[b] |
| | | | (0.0287) |
| Lambda | | | 0.0732 |
| | | | (2.7612) |
| Model $\chi^2$ | 24.68[b] | 97.49[b] | 73.03[b] |
| Adjusted $R^2$ | — | — | 0.27 |
| Correct predictions: | | | |
| Perceive SE problem ($n = 96$) | 77.88 | | |
| Do not perceive SE ($n = 201$) | 64.37 | | |
| Overall | 69.70 | | |
| Adopters ($n = 162$) | | 72.84 | |
| Non-adopters ($n = 136$) | | 69.12 | |
| Overall | | 71.14 | |

[a]Adjusted for sample selection bias.
[b]Significant at 0.01 level.
[c]Significant at 0.05 level.
Figures in bracket are standard errors.

each model a Hausman test (Greene, 1997) rejected simultaneity bias. Moreover, in the effort model which is estimated on a subsample of adopters sample selection has been taken into account by means of Hecckman's (1979) two-step estimation procedure. Finally, each model was estimated by means of a backward stepwise procedure. That is, we started off with the full model as hypothesized in Table 1. Each model was simplified by deleting one variable at the time. A wrong sign was used as a first selection criterion: if the estimated coefficient had a wrong sign and if deletion was acceptable on theoretical grounds, the variable with the wrong sign was deleted. Next, highly insignificant variables ($p$-values $> 0.20$) were deleted starting off with the variable with the largest $p$-value. Again, deletion also had to be acceptable from a theoretical point of view.[6]

The predictive power of the perception model (about 70% overall) is satisfactory. Sex, marital status, participation in SWC programmes and the level of exposure to conservation activities were identified as the determinants of perception. The results indicate that the probability of perceiving the soil erosion problem is higher for male than for female heads of households. Also, participation in activities of SWC programmes increases perception. Being single and the duration of exposure to conservation activities (DIST) have a negative influence on perception. The fact that perception is lower among singles could be due to difference in access to information. Married heads of households are likely to have more opportunities to direct or indirect interaction. Contrary to expectation, perception of the soil erosion problem is lower among households residing in the west Usambara mountains than for households residing in the north Pare mountains. This result could be due to the fact that this variable picks up other differences between the regions than differences in duration of participation in SCW programmes, e.g. cultural differences. The overall conclusion with respect to the perception model is that although its predictive power is quite good, its explanatory power needs further improvement. An important aspect in this regard is the disentanglement of effects which have been affected by multicollinearity. For instance, age, education and participation in SCW programmes are correlated. Moreover, the operationalization of perception may need further attention. Improvement of the explanatory power of the perception model is an important and interesting aspect of future research.

The predictive power of the adoption model is quite similar to that of the perception model. Its explanatory power on the other hand is higher and in line with the theoretical notions described above. The decision whether or not to use improved soil conservation measures is determined by economic rank of the household indicated by cash crop and farm size. In addition to economic rank, participation in SWC programmes and in labour-sharing groups (*kiwili*/*vikwa*) are important incentives to use improved soil conservation measures. Household ranking of soil erosion as a priority problem also plays a major role in adoption of improved soil conservation technologies. The results also indicate that households' knowledge or recognition of soil erosion

[6] The present selection procedure is typical for backword selection and in line with Hendry's methodology (see e.g. Maddala, 1992).

increases the likelihood of adoption. Furthermore, households with off-farm income are less likely to use improved soil conservation measures. Possible explanations are that off-farm income earning activities reduce the time available for farm work and that off-farm income earners may have little concern about land quality due to their orientation towards off-farm earnings.

It should be observed that although knowledge and recognition of soil erosion (which are closely related to perception) have positive influences on adoption, there exist heads of households who recognize the erosion problem but have not adopted improved erosion control measures (39%). Also, there are households who have adopted improved conservation measures but do not recognize the erosion problem (43%).[7] The former group is either unable or unwilling to adopt. Possible reasons could be lack of access to technical information or socio-economic and cultural barriers. The latter group consist of heads of households who do not recognize the soil erosion problem but in spite of that decide to adopt improved conservation measures. A possible reason could be that by means of adoption they have access to the services provided by SWC programmes such as fertilizers. An additional reason may be that adoption improves social status and opens up interaction with extension officers.

The adjusted $R^2$ of the effort model is low, but not unusual compared to similar studies (see amongst others Lynne et al., 1988). Socio-economic and institutional factors influence the level of investment. The same applies to the support received from SWC programmes. The availability of family labour and the way households rank the soil erosion problem are also important determinants of the level of resources devoted to conservation among adopters. Other determinants of the level of investment among adopters are the level of education, participation in labour-sharing groups and the region in which the household is located. Off-farm income has a significant negative impact, as in the adoption model.

The following observations apply. First, the explanatory variable perception did not have a significant influence on adoption nor on effort. This could be a consequence of multicollinearity, i.e. the high correlation between perception and knowledge of erosion at own land and ranking of erosion as a priority problem.[8] Secondly, contrary to expectation the "financial" variables cultivation of cash crops and farm size have a positive impact on adoption but not on effort. A possible explanation is that conservation measures are relatively labour intensive and that there exist substantial scale effects with respect to capital investments. For instance, adoption may require investment in equipment which in its turn requires a minimum farm size and the production of cash crops. Once the investment has been made, it can be used for one (adoption) or several (effort) conservation measures. This is the more likely if conservation measures are taken subsequentially rather than simultaneously. In line with this is the positive impact of family labour on effort. Thirdly, the relevance of extension visits and education on the level of investment but not on adoption is at first sight also implausible. A possible explanation is the following. By definition adoption comes down to taking at least one improved conservation measure which requires limited information. More than one measure is likely to require more knowledge, in particular if subsequent measures are technologically more advanced.[9]

The main findings of this section can be summarized as follows. The main factors determining perception of soil erosion are sex, marital status, participation in SWC programs and the level of exposure to SWC activities. Knowledge and recognition of soil erosion have a positive impact on the decision to adopt, although there are adopters who have poor knowledge of or do not recognize soil erosion and vice versa. Other determinants of adoption are economic rank, participation in SWC programmes, and participation in labor-sharing groups. Off-farm income on the other hand has a negative impact on adoption. The level of investment in adoption measures is positively influenced by support from SWC programmes, the availability of family labour. Off-farm income and the level of exposure to SWC programmes (DIST) have negative effects and the household's ranking of the soil erosion problem. We observe that these findings are globally in line with other empirical studies of adoption behaviour (see Boahene et al., 1999; Boahene, 1995 and the references therein).

## Conclusions and policy implications

The main objective of this paper is to analyse household adoption behaviour of improved soil conservation in the North Pare and West Usambara Mountains of Tanzania via the identification of the socio-economic determinants of the three-step adoption decision process. On theoretical grounds we assumed the adoption process to be made up of the stage of perception followed by the decision to adopt which is followed by the decision on the level of investment in soil conservation measures. From the empirical analysis we conclude that characteristics of the head of household, in particular sex, marital

[7] See Appendix I.

[8] Deletion of these variables led to a substantially lower $p$-value (i.e. increased the significance) for perception.

[9] It goes without saying that these explanations are hypothetical and need further investigation.

status and institutional factors, especially promotional activities conducted by SWC programmes are the main determinants of perception of the soil erosion problem. The study also demonstrates that the decision to use improved soil conservation technologies and the level of investment in conservation are determined by common and different factors. Both are influenced by participation in SCW programmes, the ranking of soil erosion as a priority problem and labour sharing. Adoption is furthermore positively influenced by the production of cash crops, farm size and knowledge of erosion whereas the level of investment is strongly affected by the availability of family labour, the level of education and negatively by the duration of the SCW programme. Moreover, we have found that because of labour intensity and scale effects, cultivation of cash crops and farm size have a positive effect on adoption. Off-farm income hampers adoption. Moreover, this off-farm income has a negative impact on the level of investment.

The empirical findings only partially support the sequential decision process postulated for adoption. The perception of the soil erosion problem is not a sufficient condition for using effective soil and water conservation measures. Those who perceive but do not adopt may be unable or unwilling to do so. Neither is perception a prerequisite for adoption. The latter might be due to the influence of promotional activities and support services offered by soil conservation programmes in the area. These services might motivate a substantial proportion of farmers to use improved conservation technologies despite lack of understanding of the causes of soil erosion. They seem to be "bribed" by "fringe benefits" such as fertilizers and social status.

The question arises whether this kind of adoption is sustainable. It goes without saying that sustainable use of improved soil conservation measures critically depends on the extent to which adopters understand and feel the need for controlling soil erosion. In as far as it depends on fringe benefits rather than on understanding, adoption is likely to be abandoned if the circumstances which triggered adoption off change. This applies in particular to the possible withdrawal of the programmes. This implies that for successful implementation of soil conservation activities the programmes need to be designed in such a way that they not only support farmers who are able and willing to solve the erosion problem, but also increase knowledge about the problem itself among non-perceivers. In as far as there are farmers who perceive soil erosion but are unable to adopt, strengthening and expansion of the SCW programmes could be a solution.

From the empirical findings we learn that encouraging adoption through institutional support is crucial. Therefore, government commitment is required to strengthen, expand and support long-term soil conservation programmes in the area. This also includes support for research and extension services to facilitate soil and water conservation technology generation and dissemination. To ensure sustainability of activities initiated with donor-funded assistance the government should institutionalize these efforts by incorporating these activities into the existing government-supported national agricultural extension and research system, and design strategies and mechanisms e.g., budgetary commitment, to ensure continuity after (foreign) support is terminated. This is important because foreign support to extension and research in agriculture is usually short- or medium-term lived, although there is much variation over time and countries (Semgalawa, 1998).

For the SWC programmes to attain their aspired goals of reducing soil erosion and improve land productivity deliberate effort should be devoted to: (1) identifying the existing categories of non-adopters; (2) establishing the reasons why these households are unable or unwilling to adopt; (3) designing suitable strategies that can be used to promote willingness and ability to use improved soil and water conservation measures, taking into consideration attitudes and behaviour towards the soil erosion problem; (4) identifying adopters who are non-perceivers and (5) promoting knowledge about the causes of soil erosion among them. This approach is necessary for targeting the support services to different needs of various groups of households. It should be observed that this will not only ensure an accelerated rate of adoption but will also make the programmes more cost-effective.

Appendices I and II appear on pp. 334 and 335.

## Appendix I. Characteristics of adopters and non-adopters

| Variable | Description | Adopters $n = 162$ (54%) | Non-adopters $n = 138$ (46%) |
|---|---|---|---|
| **Hh characteristics:** | | | |
| AGE | Average age of head of household | 52.31 | 53.76 |
| EDUC | Education (a.v. school yrs) (%) | 4.25 | 3.54 |
| HSEX | Gender of head of households | | |
| Male | % Male | 63.00 | 58.00 |
| Female | % Female | 37.00 | 42.00 |
| ETHN | Ethnic group (% immigrant) | 18.00 | 14.50 |
| WEALTH | Wealth category of hh (%): | | |
| High | Proportion in high category | 20.00 | 16.00 |
| Average | Proportion in average category | 41.00 | 40.00 |
| Low | Proportion in low category | 40.00 | 44.00 |
| MAST | Marital status of head of hh. | | |
| Single | %Single | 12.30 | 18.10 |
| Married | %Married | 87.60 | 81.80 |
| FSIZE | Average family size | 5.91 | 5.19 |
| **Economic factors:** | | | |
| INCOME | Annual average income ('000Tsh) | 206.20 | 162.40 |
| LABOR | Average family labour | 3.95 | 3.43 |
| RISK | Risk averse (%) | 85.00 | 83.00 |
| FASZ | Average farm size (acres) | 5.64 | 4.42 |
| OFINC | Has off-farm income (%) | 72.20 | 25.00 |
| TENURE | Owns all land (%) | 87.70 | 87.70 |
| REMIT | Receives remittances (%) | 59.90 | 25.00 |
| CASHCRO | Cultivates cash crop (%) | 84.00 | 66.00 |
| EFFORT | Average physical cons. Measures | 1.50 | 0.00 |
| **Sociological factors:** | | | |
| BENTUDE | Prefers future benefit (%) | 35.00 | 9.00 |
| CONTUDE | Positive conservation attitude (%) | 95.00 | 93.00 |
| EROKNO | Hh knows has soil erosion (%) | 86.00 | 76.00 |
| ERORANK | Soil erosion priority problem (%) | 59.00 | 43.50 |
| PRODTRE | Soil productivity is declining (%) | 72.80 | 82.60 |
| PERCEPRO | Perceives soil erosion problem (%) | 57.00 | 39.00 |
| SOST | Social status (%) | | |
| High | Proportion with high status | 23.50 | 10.10 |
| Average | Proportion with average status | 32.70 | 16.70 |
| Low | Proportion with low status | 43.80 | 73.20 |
| **Institutional factors:** | | | |
| EXCON | Has contact with extension (%) | 67.30 | 50.00 |
| EXVIST | Average # of extension visits | 15.40 | 8.00 |
| CONPROG | Participate in SWC prog. (%) | 70.40 | 23.90 |
| LABSHA | In labour-sharing groups (%) | 50.00 | 3.90 |
| INFSO | Average # of information sources | | |
| **Physical factors:** | | | |
| EROPOT | High soil erosion potential (%) | 27.00 | 12.00 |

## Appendix. II. Characteristics of perception of soil erosion

| Variable | Description | Perception $n = 203$ (67.7%) | No perception $n = 97$ (32%) |
|---|---|---|---|
| **Hh characteristics:** | | | |
| AGE | Average age of head of household | 53.04 | 53.04 |
| EDUC | Education (Average school years) | 4.13 | 3.49 |
| HSEX | Sex of head of household | | |
| Male | % Male | 60.60 | 60.80 |
| Female | % Female | 39.40 | 39.20 |
| MAST | Marital status of head of household | | |
| Single | %Single | 18.20 | 8.20 |
| Married | %Married | 81.80 | 91.70 |
| **Sociological:** | | | |
| CONTUDE | Positive conservation attitude (%) | 94.50 | 93.70 |
| ERORANK | Soil erosion priority problem (%) | 56.70 | 42.30 |
| PRODTRE | Soil productivity is declining (%) | 74.90 | 82.50 |
| SOST | Social Status (%) | | |
| High | Proportion in high status | 18.70 | 14.40 |
| Average | Proportion in av. status | 25.60 | 24.70 |
| Low | Proportion in low status | 55.70 | 60.80 |
| **Institutional:** | | | |
| CONPROG | Participate in SWC progr. (%) | 57.80 | 32.40 |
| EXCON | Has contact with extension (%) | 59.10 | 59.80 |
| INFSO | Average # of information sources | 3.58 | 2.30 |
| DIST | District (%) | | |
| Noth Pare | Proportion in the north Pare | 48.30 | 22.70 |
| West Usambara | Proportion in the west Usambara | 51.70 | 77.30 |
| **Physical:** | | | |
| EROPOT | High soil erosion potential (%) | 17.80 | 21.60 |

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