Environmental Degradation and Intra-Household Welfare: The Case of the Tanzanian Rural South Pare Highlands

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DEDICATION

I dedicate this work to my parents, Lucian Kikude and Anna Francis; and to my brothers, Sebastian and Willifred Kikude. To them, this is a fulfilment of their hard-fought educational urge.

ABSTRACT

The rural South Pare highlands in Tanzania experience a deteriorating environmental situation. Of particular importance is the disappearance of forests and woodlands. The consequences are declining amounts and reliability of rainfall, declining amounts of water levels and loss of biodiversity. Deterioration of environmental resources increases costs of collecting environmental products, which in many respects have no feasible close substitutes. One of the major components of the increased costs is labour time allocated by household members to collecting environmental products and/or grazing activities.

This study presents an empirical investigation of the impact of this reallocation of intra-household labour resources on livelihood for different members of a household. We used cross-sectional data. To analyse how variations in environmental degradation affect intra-household labour allocation, three types of areas were distinguished: severely-degraded, medium-degraded, and non-degraded environments.

Our findings show that (1) the environmental products collection and/or grazing activities were gender biased with husbands specializing in grazing while wives and children fetching water and fuel wood; and labour time allocation was significantly influenced by environmental condition; (2) environmental degradation was limiting the production and consumption potentials in the area and a limited adoption of agricultural modernization further aggravated this problem; (3) factors like school crowdedness, illness, bad weather, poor school quality, and school absenteeism due to street vending contributed negatively to the probability of primary school attainment for children apart from the environmental degradation situation; and (4) subjective welfare and well-being of household members were affected by the quality of the environment.

This study contributes to the understanding of the situation and setting proper measures towards solving the problems of sustainable development, poverty alleviation, environmental policy, and human capital formation in South Pare.

Key words: Environmental degradation, intra-household labour allocation, welfare.

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BIDS	Bangladesh Institute of Development Studies
CBBP	Cross Border Biodiversity Project
DS	Domain Satisfaction
EAAE	European Association of Agricultural Economists
EAMD	East African Meteorological Department
ECH	Economics of Consumers and Households group of Wageningen UR
ECTS	European Credit Transfer System
ESDP	Education Sector Development Programme (of Tanzania)
FAO	Food and Agriculture Organization of the United Nations
FRA	(Global) Forest Resource Assessment
FS	Financial Satisfaction
GER	Gross Enrolments Rates
GOT	Government of Tanzania
IAREP	International Association for Research in Economic Psychology
IEQ	Income-Evaluation Question
IFPRI	International Food Policy Research Institute
IHS	Integrated Household Survey
ILO	International Labour Organization of the United Nations
IQ	Intelligence Quotient
ISINI	International Society for Intercommunication of Ideas
LPRI	Livestock Production Research Institute
MNRT	Ministry of Natural Resources and Tourism
MTNRE	Ministry of Tourism, Natural Resources and Environment
NAKE	Netwerk Algemene en Kwantitatieve Economie
NEMC	National Environmental Management Council
NSO	(Malawi) National Statistics Office
OECD	Organization of Economic Cooperation and Development (countries)
OLS	Ordinary Least Squares
PEDP	(Tanzania) Primary Education Development Plan
SADCC	South African Development Coordination Conference
SAGE	Schooling-for-Age or Grade-for-Age
SARDC	Southern African Research and Documentation Centre
SSA	Sub-Saharan Africa
SUA	Sokoine University of Agriculture
SWB	Subjective Well-Being
TADREG	Tanzania Development Research Group
TGNP	Tanzania Gender Networking Program
Tsh	Tanzanian Shilling
UK	United Kingdom
UNEP	United Nations Environmental Program
UNIMA	University of Malawi
URT	United Republic of Tanzania
US	United States
USD	United States Dollar
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
2SLS	Two-Stage Least Squares

GLOSSARY

Kande	Mixture of fine small pieces of maize cobs boiled together with some beans
Kaya	Homestead
Kiangazi	Dry Period
Masika	(Long) rainy season
Mchili	Pare (tribe) headman
Msitu	Forest
Ndiva	Pare noun for water conservation project
Pori	Fallow land
Shamba	Field
Ugali	Stiff porridge prepared from maize flour
Valao	Pare (tribe) clan chief
Vuli	Short (periodic) rainy season

CHAPTER 1

GENERAL INTRODUCTION

1.1. Introduction

In many rural areas of developing countries like Tanzania, forests and woodlands still form a large part of the local environmental resources base. Forests and woodlands under communal property rights and those under government ownership provide benefits to members of nearby societies to sustain their livelihoods (Dasgupta, 2001). The reliance on local commons is prominent in semi-arid regions and mountain regions (Chopra, et al. 1990). It has been pointed out that this reliance is a reflection of a low standard of living in these areas (Cavendish, 1999). For instance, the World Bank (1996) shows that local communities in many parts of Sub-Saharan Africa (SSA) depend more heavily on their local environmental resource base than in any other region in the world. Moreover, SSA has experienced severe land degradation, deforestation, lack of access to safe water, and substantial loss of biodiversity, resulting in an even lower standard of living.

Many parts of Tanzania have experienced a deteriorating environmental situation. One of these parts is the rural South Pare highlands in the northern highlands of Tanzania (MTNRE, 1994; Semgalawe and Folmer, 2000). The causes of environmental degradation are cited as population growth (Kaoneka, 1994), deforestation, poor farming techniques, and weak forestry regulatory frameworks (Dewees, 1996). Of particular importance is the disappearance of forests and woodlands (Newmark, 1998). The consequence are declining amounts and diminished frequency of rainfall (Huwe, 1988), lower water levels and loss of biodiversity (Rodgers, 1993).

Deteriorating environmental resources increase the costs of collecting environmental products, which in many respects have no feasible close substitutes (Cavendish, 1999; Dasgupta, 2001). One of the major components of the increased costs is labour time allocated by household members to collecting environmental products and/or grazing activities. This reallocation of intra-household labour resources may have different effects on welfare for different members of a household. In less-developed communities like South Pare, in rural Tanzania, where private property rights are ill-defined or are biased against women, and where some of the markets are non-existent, degradation of the local environmental resource base is expected to adversely affect women and children more than men. Furthermore, labour time reallocation may interfere with labour allocated to other agricultural activities in the area. In addition, it could drain much of the time children allocate to schooling activities, which may have negative implications on their performance in schools and the quality of their human capital in the long run. Lastly, intra-household labour resource reallocation may influence the subjective economic welfare and well-being of individuals in the households.

1.2. Problem specification

Though it has become common knowledge that the rural South Pare highlands of Tanzania face deteriorating environmental resources (Mduma, 2001), many questions with regard to its effects on intra-household labour allocation, agricultural labour production, household

consumption of home-produced meals, primary school attainment of children, and subjective welfare and well-being of the individuals in the households have remained unanswered. For example, what effects do degraded environmental conditions have on intra-household labour allocation to collecting environmental products? What proportion of an increase in cost of collecting environmental products is borne by women in the household? What factors determine the allocation? How does the increase in labour required for collecting environmental products affect agricultural labour production? How is children's time allocation affected by environmental degradation? Are there variations in these effects between girls and boys? What factors determine these variations? How is school attendance and progress of children at primary school level affected by degraded environments? Is this effect symmetric across the two genders? How is subjective welfare and well-being of individuals in the households affected by environmental degradation? Etc.

The interactions between environmental degradation and intra-household activities are presented in Figure 1.1. Figure 1.1 shows land degradation and deforestation as elements of environmental degradation which consequently leads to scarcity in fuel wood, water and animal grass provisions.

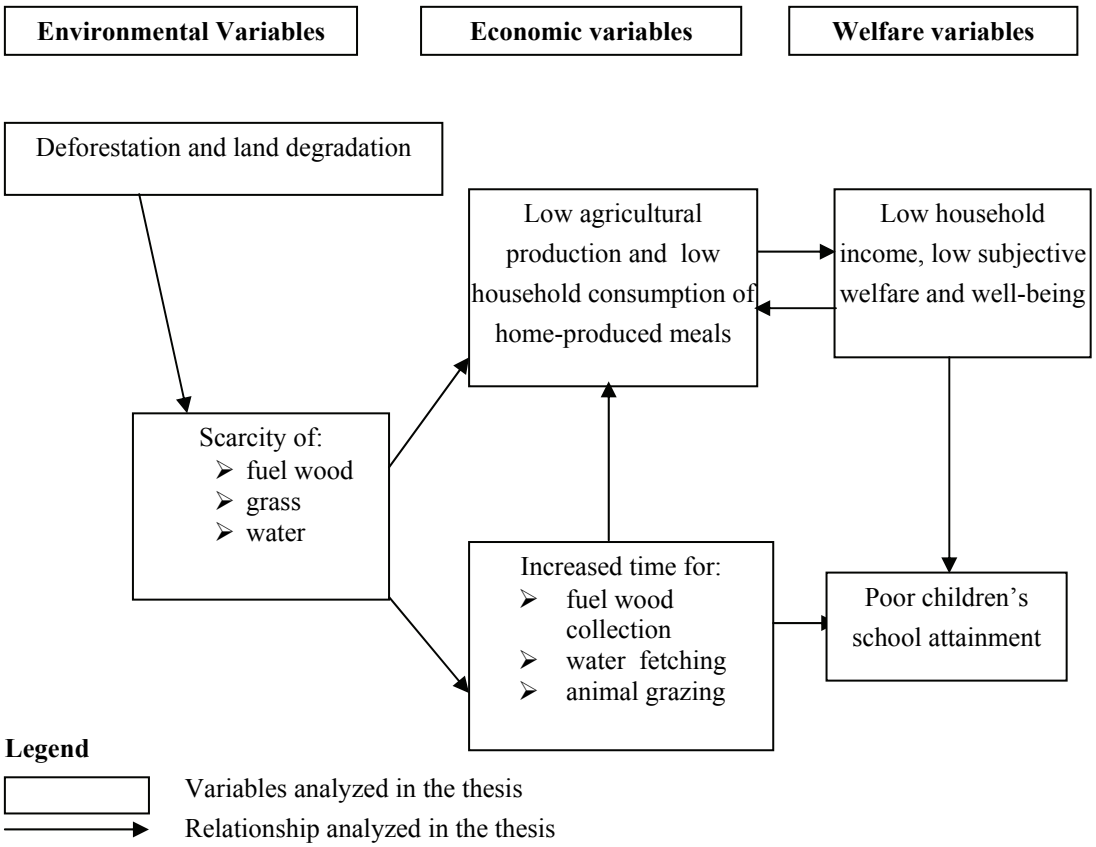
The study specifically investigates whether long hours of work spent by household members in fuel wood collection, water fetching and out-door grazing affect intra-household labour patterns in the first place. This comprises Hypothesis 1 (see Section 1.3). That is, how much did each family member have to reallocate his/her time for other production activities like farm and/or house work within the past 12 months because of spending too much time on fuel wood collection, water-fetching and/or animal grazing? Seasonality might also matter. So, it is investigated in which season[1] each family member had to reallocate his/her time for other activities most often so that he/she could fetch water, collect fuel wood for the household and attend animals in the grazing activity. In the second place, the study examines if this hypothesized increased environmental product collection and/or grazing time leads to lower agricultural production and household consumption of the home-produced meals (Hypothesis 2). The two effects, namely increased collection and/or grazing time and lower production might have further impacts on welfare. Thus, in the third place the study assesses the extent of the influence of increased collection time by school-age children on their probability of attending school and the probability of progressing at the right age for class category (Hypothesis 3). The study, lastly, investigates the impact of environmental degradation on subjective welfare and well-being of individuals in the households (Hypothesis 4).

Even though several studies have identified the extent of environmental degradation in Tanzania[2] very few (if any) formal economic studies have attempted to analyze the above effects. Moreover, very few studies in other countries have paid attention to the effects of scarcity of environmental products other than fuel wood (Kumar and Hotchkiss, 1998; Bluffstone, 1995; Mekonnen, 1998). Furthermore, these studies remain silent on the implications environmental degradation has on intra-household labour allocation and school

[1] There are two seasons in a year. The rainy season is in March, April, May, October, November and December while the dry season takes place in January, February, June, July, August and September.

[2] See for example Campbell (1996), Dewees (1994, 1996), Holmes (1995), Sjöholm et al. (1995), URT (1998), Wily et al. (1995, 1996 1997, 1998), and Wily at el. (1999), Semgalawe (1998) and Semgalawe and Folmer (2000), Ilahi (2000), Sano (1996).

progress. This study therefore presents an empirical analysis of these effects in South Pare, thus complementing other studies.



Source: *Adapted and modified from Nankhuni (2004)*

Figure 1.1. Interactions between environmental degradation and intra-household activities.

1.3. Hypotheses to be tested

This study seeks to test the hypotheses that:

1. the deteriorating environmental resources have an "adverse impact"[3] on intra-household labour allocation;
2. Environmental resource scarcity[4] leads to low agricultural production and household consumption of the home-produced meals;
3. the school attendance and progress of children in rural primary schools, with respect to their gender, is inversely affected by deteriorating environmental resources; and
4. the household subjective economic welfare and well-being are inversely affected by deteriorating environmental resources.

[3] Adverse impact refers to increased household labour allocated to collecting environmental products whose burden heavily falls on women and children. See Cooke (1998), Ilahi (2000) and Calvo (1994).

[4] The scarce environmental resources here refer to fuel wood, grass and water.

1.4. The study objectives and significance

The main objective of the study is to examine, in depth, the environmental degradation and intra-household welfare with a focus on the rural South Pare highlands in Tanzania. Specifically, the study intends to:

1. analyze how agricultural production, household consumption of home-produced meals, and intra-household labour patterns are affected by environmental degradation;
2. establish the link between the time allocated by boys and girls of school age to collecting environmental products and their attendance and progress at primary schools; and
3. assess the influence[5] of environmental degradation and subsequent changes of intra-household labour patterns on subjective welfare and well-being of individuals in the households.

This study on environmental degradation and intra-household welfare is significant for problems of sustainable development, household poverty, environmental policy and the position of women for the following reasons:

1. it would contribute to our understanding of the determinants of intra-household labour resource allocation;
2. it would point out possible inadequacy of agricultural production caused by effects of environmental degradation at the household level;
3. it would also show how gender targeting could enhance welfare of each member of the household, which is the ultimate goal of the on-going war against poverty as launched by the governments of less developing countries, donors, and the international community at large (URT, 2006); lastly,
4. it would provide a strong stimulus for the development and implementation of environmental policy because of the negative impacts of environmental degradation on agricultural production and, in the long run, on investment in human capital.

The results from this study would be used as building blocks for various policies in Tanzania and similar countries, notably in Africa.

1.5. The study area

The study covers Tanzania's rural South Pare highlands. South Pare is the most dramatic example of environmental degradation in Tanzania. The area is identified as having inadequate food-production and deteriorating water supply, thus highlighting a state that needs immediate concern (Maghimbi, 2007).

[5] The influence underlies a causal model that environmental degradation leads to changes in intra-household labour patterns which consequently might affect subjective welfare and individual well-being of the household members.

1.5.1. Description of the study area[6]

The South Pare highlands are entirely confined to the Same district, with a land size of 5,152 square kilometres, which is 39 percent of the total area of Kilimanjaro region. Same district is the largest of the five districts forming the Kilimanjaro region. The district is situated South- east of the region and it borders Mwanga district to the north, Simanjiro district (which belongs to Arusha region) to the west and south-west, Lushoto district to the south-east , Korogwe district to the South, and the Republic of Kenya to the north-east.

Part of South Pare is a mountain block that reaches up to 2,462 m altitude and cover about 25,000 ha (about 250 square kilometres) in area (www. Easternarc.or.tz/spare). This mountain block lies between the North Pare mountains and the West Usambara mountains in north-eastern Tanzania. The site is separated from West Usambara mountains by the Mkomazi river valley, a 20 km wide corridor of arid *Acacia-Commiphora* woodland. The highest point of the South Pare mountain block is the Shengena peak at 2,462m within Chome Forest Reserve. The whole block drains south-eastwards through the Mkomazi river and into the Pangani river. The soils in South Pare were originally fertile, but currently are highly eroded with low organic matter, nitrogen and phosphorous (Fungameza and Frischenich, 1992).

The South Pare highlands are categorized into three main zones as per their geographical features, which influence the climate and associated agro-economics. The zones are the Upland Plateau Zone, the Middle Plateau Zone and the Lowland Zone. Each zone faces some form of environmental degradation to a different degree.

The Upland Plateau Zone lies 1,100–2,462m above sea level. This zone is densely populated with 650 people per square km. The zone receives relatively high rainfall that ranges from 1,250 – 2,000mm per annum. Temperature in this zone ranges between 15^0C – 25^0C. The arable land in this zone has been fully utilized whereby farming is the main economic activity of the people. The crops grown are coffee, bananas, maize, beans, cardamom and various fruits such as pears, paw paws, avocados, etc. The zone is also famous for producing vegetables such as tomatoes, onions, spinach, lettuce, okra, pepper etc. The villages surveyed in this zone are Gwangá (in Chome ward), Gonjanza (in Suji ward) and Kirangare (in Kirangare ward). This zone is considered non-degraded[7].

The Middle Plateau Zone has an altitude ranging 900 – 1,100m above sea level. The zone has a population density of 250 people per km^2 and experiences rainfall ranging from 800 – 1,250 mm per annum. The temperature varies between 25^0C – 30^0C. The crops cultivated include maize, beans, fruits, vegetables, coffee and timber tree such as grevillea, sedrella, and pines. The villages surveyed are Mgwasi (in Makanya ward), Kizungo and Vumari (in Njoro ward). This zone is medium-degraded.

The Lowland Zone rises from 500 to 900m above sea level and it experiences rainfall ranging between 500 – 800mm per annum. The zone has a population density of about 140-200 people per square kilometer. This Zone is semi-arid. The zone has a polulation density of about 140-200 people per square kilometer. Apart from crop cultivation, livestock out-grazing is dominantly practiced here. Crops grown include maize

[6] See Figure 1.2: Location of the South Pare Highlands

[7] The criterion used to classify environmental degradation is explained in chapter 3, Section 3.3.1. under the sub-title "Environmental quality." (see also Svein and Krigsvoll, 2003).

and beans. The villages surveyed are Mvure-Kongei (in Kihurio ward), Mgandu (in Bendera ward), Njoro and Ishinde (in Njoro ward). This zone is severely-degraded.

1.5.2. Data collection

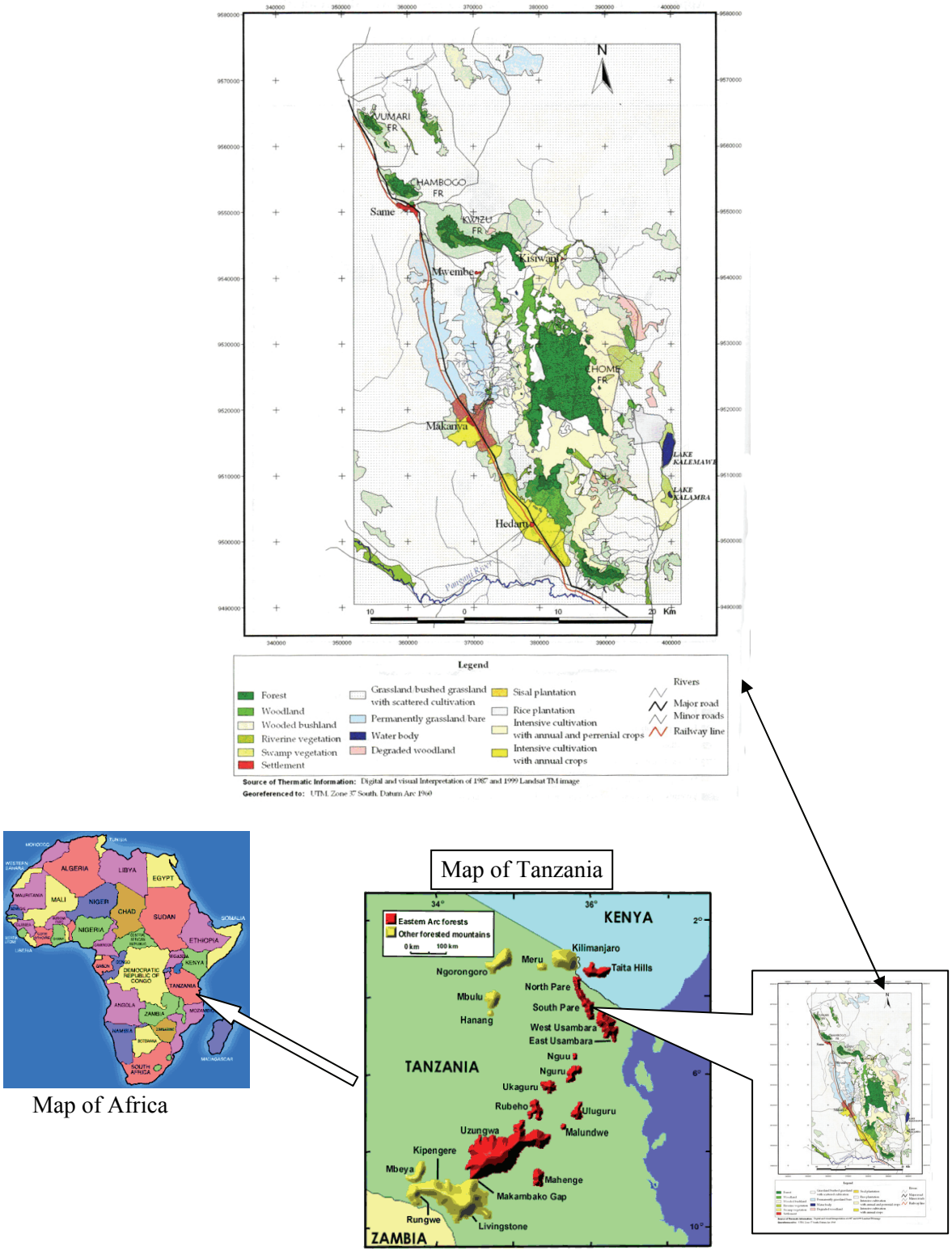
A pilot survey including 10 households preceded the main research to pre-test the survey instruments, get a better understanding of the study area, observe the environmental situation prevailing in the area and assess socio-economic characteristics of the households. Such an understanding was useful for refining the scope of the research problem, identifying major information gaps, designing and preparing the main household research. The pre-tested questionnaires during the pilot research were later critically examined for cultural and language conformability.

Later, the main research was conducted. With the help of the local authority, ten villages were selected for the survey through stratified random sampling procedures[8] (3 villages from each of the upland and middle plateau zones, and 4 villages from the Lowland Plateau zone were chosen). The selected villages are *Gwangá, Gonjanza, Kirangare, Mgwasi, Kizungo, Vumari, Mvure Kongei, Mgandu, Njoro and Ishinde.* At least 30 households from each survey village were randomly selected. A total of 90 households were interviewed in the upland plateau, 91 households in the middle plateau, and 120 households were interviewed in the lowland-plateau zone because 54 percent of the area population is found in the Lowlands. . The structured questionnaires[9] were administered to 301 husbands, 301 wives, and at least one schoolboy/girl in each household thus making 903 interviews in total.

Questions were asked to obtain information on six general areas: 1) household characteristics; 2) environmental products collection; 3) farm production systems; 4) household production systems; 5) household income and; 6) subjective economic welfare and well-being. Questionnaire surveys were conducted in order, among others, to gather information on the household demographic factors such as size, age of the family members, their gender, education level and their relationships to the household head; fuel wood, water and grass collection and utilization patterns; major crops cultivated, yields, consumption and incomes; domestic chores time patterns and individual satisfaction issues. Since both farm and home activities may be affected by the seasons, care was taken to consider seasonal allocation of family labour. Respondents were also asked to state their daily average consumption of these environmental products and daily time spent on grazing by season.

[8] A three-staged sampling procedure was adopted. Firstly, 83 villages were sorted out by a stratification technique (Arndt and Preckel, 1996), using population, number of households, state of environmental degradation and geographical zone as parameters. Secondly, from among those 83 villages, 10 were selected for the household survey. Lastly, the households were randomly selected according to the a-priori set criteria of a household having both parents living together and at least a child in their midst.

[9] The questionnaires were translated into Kiswahili, the national language, to avoid translation discrepancies among the enumerators during the interviews.



Source: The Tanzania Forestry Research Institute (TAFORI).

Figure 1.2. Location of the South Pare Highlands.

1.6. Thesis outline

This study is organized into seven chapters, including this introductory chapter. Chapter 2 provides an overview of environmental conditions of the South Pare highlands

focusing on the state of environmental degradation and its linkage to intra-household material welfare. The chapter presents the current state of the environment in the rural South Pare highlands, explains the implications of the environmental problems on provision of environmental products such as fuel wood, fresh water and food, and it explains the link that exists between environmental degradation and intra-household material welfare. The chapter, in turn, supplements the analysis of the subsequent empirical chapters..

Chapter 3 shows empirical findings and analysis of the results on environmental degradation and household labour patterns, testing Hypothesis 1. We are interested, in this first objective, in assessing whether increased collection time due to environmental degradation alters the time-use patterns of each of the household members. We also examine the consumption of environmental products and the allocation of time across tasks and household members. Lastly, we determine whether there are gender differences with regard to time allocation, as is frequently assumed. Taking into account the effects of environmental quality, household income, the consumption in kilograms/litres of meal-related environmental products (fuel wood and water), and of agriculture-related environmental product (grass for animals) as inputs in agricultural and household production of home-produced meals in each household, vectors of fixed household characteristics, including household size, gender, and age of household members, a general equation for econometric estimation will be proposed. This will be followed by a discussion of the descriptive and econometric results.

Chapter 4 provides empirical findings and analysis of the results on resource scarcity and agricultural production and household consumption of home-produced meals, testing Hypothesis 2. We examine the influence of time spent on scarce environmental products on both agricultural and household production of home-produced meals in the study area. Starting with agricultural production, we consider the effects of time available for agriculture, collection of scarce environmental products and/or grazing, and other inputs in agricultural production processes such as the size of the cropped land, agricultural market-priced inputs, and livestock inputs as factors responsible for agricultural production. With regard to household production of home-produced meals, we take the effects of time, environmental goods used as inputs to the meal production process such as water and fuel wood and agricultural goods used in producing meals, that is; rice, millet, beans and maize as factors responsible for domestic production. Empirical specifications will be developed and analysed.

Chapter 5 deals with empirical findings and analysis of the results on environmental degradation and child labour (testing Hypothesis 3). It is believed that school-age children are involved in the work, supporting their households' livelihoods, including housework, farming, collecting scarce environmental product and/or grazing. This type of child labour frequently leads to foregone schooling, which may have critical consequences for educational achievements. While there are a number of factors that may affect attendance and school progress at the primary level, the question of how important children's work is in determining whether or not they attend school and attain desired progress at school remains. Chapter 5 attempts to consider this factor as far as it results from environmental degradation.

Chapter 6 provides empirical findings and analysis of the results on resource scarcity and household subjective economic welfare and well-being (testing Hypothesis 4). We are interested in this objective to assess the influence of environmental degradation on

the subjective economic welfare and well-being of the households. The welfare function of income will be analyzed based on the household members' responses to the fieldwork questionnaires.

Chapter 7 summarizes the study, provides policy implications, cites its limitations, and recommends areas for further research.

CHAPTER 2

ENVIRONMENTAL DEGRADATION STATUS AND INTRA-HOUSEHOLD MATERIAL WELFARE: AN OVERVIEW

2.1. Introduction

This chapter provides an overview of environmental conditions of the South Pare highlands focusing on the state of environmental degradation and its linkage to intra-household material welfare (standard of living).

A practical definition for environmental degradation is given by Tyler-Miller (2000;p.5):

"Depletion or destruction of a potentially renewable resource such as soil, grassland, forest... that is used faster than it is naturally replenished. If such continues the resource can become non-renewable (on a human time scale) or non-existent (extinct)."

Examples of such degradation could refer to the processes of land degradation, deforestation, deterioration of aquatic systems, lack of good quality water, environmental pollution and loss of wildlife habitats and biological diversity (FAO, 2003). These are also the major six environmental problems the world faces today (USEPA, 2000). The NEMC (1994) and the URT (1997) identified the same issues as the problems for immediate attention at the national level in Tanzania. Of these six, the most prevalent ones in the South Pare highlands are land degradation, deforestation and lack of accessible good quality water.

On the other hand, standard of living refers to material issues only, such as income, wealth and goods (Antonides and Raaij, 1998). We define household as a group of people living in the same dwelling and sharing at least one meal a day (Lind 2000). In the strict sense, this household definition refers to the nucleus family of two biological parents of opposite sex and at least one child. In this study, the household is taken as the unit of analysis because it is the locus where resources are generated, organized, managed and used for economic activities as well as for generating welfare of the household members and care (Niehof, 2002).

Intra-household material welfare is multi-dimensional with many constituents and determinants closely determined by the quality of the environment (Duraiappah, 2004). However, not all constituents may be under serious threat and not all of these constituents are directly dependent on the state of the environment. Therefore, only constituents and/or determinants of household material welfare directly affected by the quality of the environment are elaborated in this chapter. The discussion is focused more on the study area, Pare highlands. In some cases, comparisons with regional and national statistics are made.

The rationale for this chapter is to provide an overview of environmental conditions of the South Pare highlands focusing on the state of environmental degradation and its linkage to the household material welfare. This, in turn, supplements the analysis of the next empirical chapters.

Section 2.2 presents the current state of the environment in the South Pare highlands. Section 2.3 explains the implications of the environmental problems on

provision of environmental products such as fuel wood, fresh water and food while Section 2.4 explains the link that exists between environmental degradation and intra-household material welfare. Section 2.5 concludes the chapter.

2.2. Environmental degradation status

The current state of the environment in South Pare is a matter of urgent concern. Natural resources are being depleted, with major developmental and environmental implications. The major environmental problems discussed below are land degradation and deforestation.

2.2.1. Land degradation and its causes

Land degradation is a phenomenon resulting from a mixture of natural and human processes. It is a progressive process that starts with a loss of vegetative cover, exposing soil surfaces to the erosive power of wind and rain. However, the processes of land degradation are varied (Chuwa, 2002). Its severity can be assessed from the red-brown colour of streams and in floods as the top soil is washed away from upland areas (MTNRE, 1994). Other manifestations of land degradation include loss of fertility, bareness of the top soil in many fields, and silting of dams and reservoirs. Land degradation has been a major threat to agricultural development. It reduces yield directly via poor seedling establishment, water logging and crop burial (Semgalawe, 1998). Indirectly, land degradation affects crops through lack of nutrients (nitrogen, phosphorous and potassium) and organic matter, moisture deficiency and general deterioration of the structure of the soil (Lal, 1985).

Before the 18th century, the South Pare highlands were endowed with enormous natural resources and favourable climatic conditions offering opportunities for development (Semgalawe, 1998). In the beginning of 18th century most parts of South Pare were still covered with natural forests. The major part of the arable land was uncultivated, covered with natural vegetation. Land was owned by clans and the clan chief, *valao,* and selected headman, *mchili,* were responsible for allocating land to clan members (O'Barr, 1970:28-30; Kavugha, 1977:87; Lebulu, 1979; Kimambo, 1991:31). 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; Schenmann, 1986). Rivers were flowing and irrigation was practiced (Kimambo, 1969:80). Even in the 19th century, farmsteads consisted of two to five houses that were spread over the hillsides at some distance from each other, surrounded by their fields and banana groves (Rother, 1906). On the eastern side of the mountain, many streams and irrigation furrows crisscrossed the slopes watering fields of maize, bananas, beans, sweet potatoes, and sugarcane (Baumann, 1891:209; Fuchs, 1903). Thus, land during this time was not degraded and cultivatable land was not scarce.

In the 1920s, population started to increase at a very fast rate (Semgalawe, 1998). As the population increased, more land was put into cultivation. By 1936 all arable land was under cultivation. Between 1967 and 1978, annual population growth in Pare highlands was 3.79 percent, which was higher than the averages for Kilimanjaro region (2.99 percent) and Tanzania mainland (3.27 percent). The previous birth rates are not known with certainty because since independence Tanzania government conducted the first population

census in 1967. 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 (Semgalawe, 1998). In response to increased land scarcity at high altitudes farmers acquired lands in the lowlands 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 fuel wood (FAO, 1971). As a result of these practices, most of the land cover was removed. Formerly big rivers like *Hingilili, Yongoma, Saseni, Muhokevuta* and *Nakomb**o*** that flew over to Mkomazi valley and many springs started to dry up or to decrease in water volume[10]

Overgrazing also accelerated the rate of land degradation. The people of South Pare kept large numbers of cattle in the past before cattle epidemics and droughts arose (Farley, 1882; Baumann, 1891:245). The western slopes and plateaus, previously covered with grasses that made good pastures, were extraordinarily rich in cattle in the 19th century (Weiss, 1886). Cattle, goats and sheep ate and trampled down the young shoots of trees while herdsmen slashed and burned vegetation to open up new pastures. The movement of stock also led to the destruction of vegetation cover along their routes. With increased grazing pressure, soil erosion had become widespread. The rapid growth in animal numbers had resulted in shortage of grazing land, and animals were grazed on steep slopes where cultivation was difficult. This had led to soil compaction and increased surface runoff. Many plants had also been killed through trampling, thus laying the land bare and increasing the development of rills and gullies.

Today, South Pare experiences land degradation. The productivity of the soil has been considerably reduced in many parts. Although soil erosion is, to some extent, a natural process, it has been greatly accelerated by human activities, including poor cultivation practices and poor livestock keeping (Semgalawe, 1998). Vertical ploughing across steep slopes, failure to adopt crop rotation, failure to maintain adequate vegetative cover, inadequate use of organic fertilizer and lack of sufficient conservation measures, particularly on hill slopes, have all led to declining soil productivity and crop yields (Aune 1994). However, all these factors are deeply rooted in the socio-economic development and knowledge of the people. Factors like poverty, insecurity of tenure, and loss of traditional conservation practices and of indigenous resource knowledge, in general, all underlie the whole process of land degradation in the area. Consequently, among others, the economy, which is agriculturally based, is performing poorly and people tend to out-migrate from the area. Between 1978 and 1988, population growth rate (which was higher in the past) dropped to 2.29 percent, which was still higher than the regional (Kilimanjaro) average (2.04 percent), but lower than the national average (2.80 percent) (See Table 2.1). Population growth dropped even lower to 1.23 percent between 1988 and 2002, a rate below both the Kilimanjaro average (1.61 percent) and the mainland average (2.92 percent). Thus, the declining population trend in the Pare highlands was much faster than in Kilimanjaro region. Probably the social factors like out-migration encouraged by the poor economy might have accounted for the low population growth in this area (Ikeno, 2007).

[10] Observation by Peter A. Kisumo, *an old man November 19, 2003,* Same workshop.

Table 2.1. Annual population growth in percentages during 1967-1978, 1978-1988, and 1988-2002

	1967-1978	**1978-1988**	**1988-2002**
Pare highlands	3.79	2.29	1.23
Kilimanjaro Region	2.99	2.04	1.61
Tanzania Mainland	3.27	2.80	2.92

Source: *Ikeno, J. (2007).*

2.2 2. Deforestation and its causes

The South Pare highlands have also been experiencing deforestation problems that resulted into decrease of area under forest cover. Burgess, 2001 (see Table 2.2) estimated that South Pare highlands have lost 73 percent of their forest cover. The loss of forest does not proceed evenly with increasing altitude. On these highlands the higher altitude areas of forest are typically found within catchment forest reserves, and only some of the areas of forest have been protected in this way on the lower slopes. This has meant that the majority of the forest loss in the South Pare highlands has occurred in the lowland up to around 1000 m altitude.

Table 2.2. Description of forest cover in the Tanzanian northern highlands

Highlands	Natural forest (km^2)	Number of forest patches	Closed forest (km^2)	Loss of original forest cover (%)
North Pare	151	2	28	50
South Pare	333	5	120	73
West Usambara	328	17	245	84
East Usambara	413	8	235	57

Source: Burgess 2001

Although the local average annual deforestation rate in the area has so far not yet been computed, the national average annual deforestation rate is alarming. Between 1990 and 2000, Tanzania lost an average of 412,300 hectares of forest per year. This amounted to an average annual deforestation rate of 0.99 percent. Between 2000 and 2005, the rate of forest change increased to 1.10 percent per annum. The deforestation rate of 1.10 percent is higher than the world's average deforestation rate of 0.21 percent (FAO, FRA, 2005).

As noted earlier, the causes of this high rate of deforestation are population growth creating pressure on cultivation land (Semgalawe, 1998; FAO, 2003), dependence of population on fuel wood as a source of energy (FAO, 1999a; Monela *et al*., 1999), overgrazing, commercial felling of timber, and clearing of forests and woodlands for industrial use (mainly village industries such as brick burning). Deforestation is also accelerated by forest fires especially in the large Chome forest reserve (*www.easternarc.or.tz/spare)*.

Apart from population growth, two other causes of deforestation, namely commercial felling of timber and fuel wood as a source of household energy deserve some

in-depth explanation for the case of South Pare. The commercial felling of timber here refers to the unsustainable illegal logging practiced in the Pare reserve forests especially the Chome forest reserve. Chome forest reserve is picked here as a sample forest due to the fact that it was the largest and the focal forest for the cross- borders biodiversity project in the South Pare mountains. The 14,023-hectare forest, gazetted in 1951, was the most species-rich forest in the Pare highlands and was the most important catchment forest in Same district before it experienced deforestation (Lovett 1993). Illegal logging in Chome increased in 2002-2003 (Persha, 2003). The most comprehensive picture of the overall logging situation in Chome came from an aerial survey conducted by the Cross Border Biodiversity Project (CBBP) in April 2003. During this survey, 255 pit-saw sites were observed, of which 26 sites were actively in progress on the day of survey, that is, had planks on the ground, people working at the site, or a trunk on a pedestal for cutting (Persha, 2003). Using a weighted counting system that estimated 25 percent of sites in heavily logged areas would be missed by observers, there were at least 310 pit-saw sites in Chome[11]. Prior fieldwork in Chome showed that an average of 2 to 5 trees were cut for timber without replacement at each site. This average was used to generate an estimated range of 620 – 1550 trees logged out of the 310 pit-saw sites in Chome forest reserve alone. Persha (2003) revealed through ground surveys that the most heavily exploited tree species were camphor *(Ocotea usambarensis)* and podo *(Africarpus falcatus, Afrocarpus Latifolius; Africarpus usambarensis)* . The removal of hardwood from the forest was inefficient and wasteful, with pit-sawyers taking a small portion of the felled tree and leaving the majority of the trunk and harvestable wood untouched. Up to 30 smaller trees were cut at each pit-saw site to support the logging camp (these smaller trees were chopped down to create an open workspace and to make the platform for sawing). This created large canopy gaps in the forest that were probably too sunny for forest species to recolonise, turning the area into a degraded habitat of tangled weeds. Persha (2003) further indicated that pit sawing was rampant throughout Chome forest reserve, but was most intense in the Southern half of the reserve.

Persha (2001) also identified fuel wood collection in Pare highlands and specifically in Chome forest as one of the major causes of deforestation. In our study, firewood is defined as woody biomass used for fuel without processing, in contrast to charcoal. Fuel wood or wood fuel is a concept covering both firewood and charcoal (Johansen, 1999). Our study uses fuel wood and wood fuel interchangeably to refer to both firewood and charcoal, which are all commonly used in the area. Fuel wood is used by all households for cooking, heating, and lighting. However, a broad assessment of the fuel wood situation in the Southern African Development Coordination Conference (SADCC) region concluded that firewood collections alone by rural subsistence households does not, broadly speaking, cause deforestation (Bhagavan 1984:24). This view is also recognized by the Tanzanian Ministry of Lands, Natural Resources and Tourism (now Ministry of National Resources)(1989, annex 4:6):

[11] 219 sites were counted in "heavily logged areas". This number was increased by 25 percent to account for "missed" sites, adding 55 additional sites (25 percent of 219). (Persha, 2003).

"Supply-demand gap models therefore tend greatly to overestimate the contribution of wood fuels to deforestation, and hence the need for energy-focused remedies for it. If all wood fuel consumption ceased tomorrow, deforestation in Tanzania would not be halted." (Quoted from Johnsen, 1999).

Bhagavan (1984) argued that the subsistence farmer does not cut down a tree to obtain firewood; at most he or she breaks off branches from it. Instead, it is a contributing factor towards deforestation when it is combined with charcoal production for both household and commercial purposes. The production of charcoal is probably a much more severe cause of deforestation than firewood gathering for home consumption, because charcoal burners cut the whole tree. While assessment has not been carried out to identify how much of the woodland is cleared per year for charcoal production in the South Pare highlands, the available data set an estimation of 4,354 ha of woodland being cleared countrywide per year in order to supply just one city, Dar es Salaam, with charcoal (Monela *et al.,* 1993).

Thus, in the South Pare highlands, just like any other deforested parts of the country, there are strong indications that the forests are being destroyed following the sequences of (a) wholesale conversion to agriculture (Ramadhani, 1989); (b) wholesale burning for charcoal and to some minor extent firewood (Monela *et al., 1993)*; (c) logging for timber and pole-cutting to build houses (Johnsen, 1999); (d) overgrazing; (e) forest fires; and (f) small village industries of brick burning (Persha, 2001,2003). Kihiyo (1991) and Kikula (1997) added villagization programmes as another major driving force enhancing deforestation in rural areas (see also Lundgren, 1983). With much of the population concentrated in these villages, the pressure on land seemed to have increased and caused irreparable damage. Population pressure had also been responsible for the expansion of farming activities onto the previously forested areas (Mashalla, 1988).

The rapid depletion of the natural resources such as forestland has significant consequences for fuel wood, water and food provision.

2.3. Provision of environmental products

2.3.1. Fuel wood provision

In Tanzania, about 90 percent of the population depends on fuel wood (firewood and charcoal) as the main sources of household energy for domestic purposes (President's Office 2001, 5; GOT, 2002; World Resources Institute 2003b). The official estimate of the fuel wood situation in Tanzania is that it is being used up at about twice the rate at which natural woodland can supply it. This estimate rests on a rural consumption rate calculated to be 2.20 m^3 per head per year in 1970, dropping to 1.85 m^3 in 1985 and 1.5 m^3 by the year 2000. This fuel wood is not all for domestic use but includes an allowance of about 10 percent for rural industries and crafts and is based on the FAO study carried out in 1971 (Openshaw 1978). Other studies on the subject give both lower and higher results. The Rural Integrated Development Plan for Mwanza and Shinyanga regions, areas also hit by environmental degradation, found consumption to range from 0.41 m^3 in a wood-poor zone to 1.5 m^3 in areas where forest was still visible; the average was found to be 0.71 m^3 per head per year (Gulluisson and Person, n.d.). Meanwhile, a study in the mountainous

Lushoto area, an adjacent highland to Pare highland with almost similar characteristics, measured an average consumption of more than 4.0 m^3 per year (Fleuret 1978).

Tanzanian fuel wood consumption figures are high relative to those for other African countries shown in Table 2.3. Comparable studies from Machakos district in Kenya, for example, estimate consumption at 1.53 m^3 per person per year, including 0.25 m^3 for crafts (Openshaw, n.d.), while in West Africa the amounts vary from about 0.7 to 0.5 kilograms (kg) per person per day, which is the equivalent of about 0.4 to 0.3 m^3 per person per year. Comparison is made to other African countries and not the rest of the world because Africa is the largest consumer of biomass energy (firewood, animal waste, charcoal, agricultural wastes) when calculated as a percentage of overall energy consumption (Chambwera 2004). Africa has the highest per capita fuel wood consumption of 0.89 m^3 per year compared to other continents (c.f. Asia: per capita fuel wood consumption is 0.3 m^3 per year) (Amous, n.d.). In sub-Saharan Africa, biomass accounts for 70-90 percent of primary energy, which is higher than in any other continent. In the Southern African sub-region, the use of wood, its dominance as an energy source, together with the associated impacts is referred to as the "fuel wood crisis" (Chambwera 2004). FAO data in Amous (n.d) shows that the annual growth rate in wood fuel consumption in Southern Africa is 1.4 percent, compared to 0.8 percent in Europe and other OECD[12] countries. The household sector is the most significant consumer of wood fuels, consuming between 74 percent and 97 percent of the total (Chambwera 2004).

Table 2.3. Estimated fuel wood consumption for various African countries (m^3/person/year)

Country	Fuel wood consumption
Malawi	0.77
Nigeria	1.00
Uganda	1.07
Kenya	0.69
Zimbabwe	0.63
Ivory Coast	1.01
Zambia	0.90

Source: *Derek (1975) quoted in Skutsch (1983).*

While Tanzanian fuel wood consumption figures are high relative to those for other African countries shown in Table 2.3, Pare highlands reported even higher fuel wood consumption rate than the average national figures. Mmakasa (2003) reported that the estimated fuel wood consumption for Pare highlands was 3.65 m^3 per person per year. This domestic fuel wood consumption excludes brick burning, pottery and other craft use. Fuel wood for brick burning was accelerated by Tanzanian Government policy strategies to encourage villagers to use burnt bricks rather than cement ones in relatively decent rural house constructions. Burnt bricks were cheaper compared to cement blocks. The average cost of a burnt brick in 1981 was 1.20Tshs while that of a cement block of comparable size was 6Tshs. In Pare highlands, brick production was estimated to be between 1.8 million bricks in 1980 and 12.17 million in 1985. The amount of fuel wood needed to burn a unit

[12] OECD refers to the Organization of Economic Cooperation and Development countries.

quantity of bricks was not known precisely. Mnzava (1981) indicated, however, that I m^3 of fuel wood stacked from an indigenous forest was enough to burn lots of 185 to 660 bricks. Thus, the amount of wood required for burning 12.17 million bricks would range from 18,440 to 65,784 m^3. However, the plains, which were the major burning areas, were already deforested and became the driest in Pare. The total annual cut for Pare area was hardly 35 percent of the above requirements. It was also estimated that Pare highlands would produce 450,000 to 500,000 pieces of pottery a year, mainly pots. Mnzava (1980) revealed that 1 m^3 of stacked *Grevillea robusta was* enough to burn 20 to 25 pots under average conditions. In 1980/81, a total of 7.9 million pottery units was likely to be produced, for which a minimum of 394,565 m^3 of fuel wood would be needed. These were estimated figures; the actual data was unavailable as a follow-up study was not conducted even though both brick burning and pottery making continued to take place!

The above situation has precipitated a chronic shortage of these renewable sources of energy in Pare highlands (Mnzava, 1980). Fuel wood gathering is becoming progressively more difficult as forests shrink further away from population centres. Field observations (2006/7) confirmed that there is shortage of fuel wood in the study area especially in the severely-degraded environment, in the lowland zone.

2.3.2. Fresh water provision

Forestry plays a key role in the provision of clean freshwater and regulating the flow of water (Donaldson and Swanson, 2001). Studies in the 1970s (Pócs, 1974; 1976) showed how the mossy forests of the higher altitude portions of the mountains were able to capture water from clouds and hold that water, releasing it slowly. This ability of forests, especially the ones covered with epiphytic plants to gather water from clouds and then pass this water gradually to watercourses was recognized over 100 years ago in Tanzania (Burgess, 2001). The forest can capture the water from the clouds, but if the clouds are gone then this is no longer possible. Deforestation changes the cloud patterns and this is probably an explanation of many of the local stories we were told by one old man[13] in Kizungo village, Same district, about the short rains becoming less frequent and the area being hotter and drier now. The old man told us that in the past, about 50 years back, when the Dido village forest surrounding the Kizungo village was still sound, some water springs were flowing from the hills to the lowland. But now the mountain is bare and all springs have dried up creating a shortage of water and lack of precipitation rains through orographic effect. When making a preliminary economic assessment of water resources of the Pangani river basin in Pare highlands, Turpie (2003) argued that forest cover encourages infiltration of water during the rainy season, which is then released gradually, maintaining flows throughout the year. But as forest and other vegetation and soil cover is degraded, less water infiltrates and more water is lost during flood periods.

The South Pare mountains, especially such big mountains like *Shengena*, *Kwanduju,* and *vumari* in Same district used to have forests which were the source of water for major rivers of *Hingilili, Yongoma, Saseni, Muhokevuta* and *Nakombo* that flow over the Mkomazi valley. The western part of the South Pare highlands did not have big rivers but small streams like *Mpombe ya Gonja* were observed to drain water in Makanya

[13] This old man aged 78, lived in this village the whole of his life. Having witnessed the current deforestation situation he has now engaged himself in the afforestation program to restore the past.

catchment. Four tributaries, *Mwembe, Vudee, Chome* and *Tae* from South Pare mountains joined to form the main stream in the Makanya catchment, which drained into the Pangani river during exceptional floods. These rivers, which are now seasonal, used to be perennial up to the late 1970s (SUA, 2003).

There were water conservation projects, locally known as *Ndiva,* constructed between 1952 and 1994 in Pare highlands to accumulate, store and supply water to the households for both domestic and irrigation purposes. These *Ndiva* previously had a total capacity of releasing about 5,488 m^3 per day, but by September 2003, reduced their water supply to the level of 1,506 m^3 per day. Some of the *ndiva*s were *Vabora* in Vudee, *Kwamachombo* in Kighare Usangi ward, *Chome, Gonja Ugweno,* and *Mashabula* in Ngulu. Most of these *ndivas* are now non-existent. The challenges facing the existing *ndiva* are still inadequacy of water to meet all the households' demands. Table 2.4 shows the *ndivas (*water projects) construction years, initial water volumes released daily to the households and their deteriorating supply capacities as recorded in 2003. The overall average percentage of decline is 72.4.

Table 2.4. Water projects, construction years, initial water volumes and their supply as in 2003

When the Project was constructed				
Project	Construction Year	Initial water supply	The 2003 supply	% decline in 2003
Usangi Chini Gravity scheme	1972	480m^3/day	120m^3/day	75.0
Usangi Juu Gravity scheme	1981	336m^3/day	84m^3/day	75.0
Kwanakimbughu Gravity scheme				
Vulue Gravity scheme	1972	108m^3/day	27m^3/day	75.0
Lambo Gravity scheme	1975	168m^3/day	32m^3/day	80.9
Mruma Pumping scheme	1972	288m^3/day	72m^3/day	75.0
Ndea Pumping scheme	1994	109m^3/day	27.5m^3/day	74.7
Kwakoa Gravity scheme	1961	288m^3/day	216m^3/day	25.0
Toloha Gravity scheme	1972	528m^3/day	132m^3/day	75.0
Kigonigoni Gravity scheme	1952	432m^3/day	108m^3/day	75.0
Ngulu Gravity scheme	1972	1200m^3/day	300m^3/day	75.0
Chanjale Gravity scheme	1992	168m^3/day	42m^3/day	75.0
Kilomeni Gravity scheme	1970	360m^3/day	90m^3/day	75.0
Kilomeni Sofe Gravity scheme	1989	216m^3/day	54m^3/day	75.0
Kiverenge Gravity scheme	1995	144m^3/day	36m^3/day	75.0
Chanómbe Gravity scheme	1994	384m^3/day	96m^3/day	75.0
Mbochiro Gravity scheme	1967	264m^3/day	66m^3/day	75.0
	1993	7m^3/day	1.75m^3/day	75.0
% overall average decline				**72.4**

Source: Kidaya (2003)

The severity of water scarcity is reflected in the time spent in fetching water for household use. Household members might walk long distances, spend many hours per day

burdened under heavy containers in their search for water. Sato (1996) made a socio-economic baseline survey in Kilimanjaro region and emphasized that water-fetching is an important task of women and children, in particular girls. Sato's survey revealed that, in Meserani for instance, a village west of Same district which is very dry and less forested savannah area, women have to travel three to five kilometres each time, spending a maximum of 2.5 hours to fetch water. In lowlands, women and children wait hours queuing for intermittent water supplies. Many then have no time for other pursuits, such as education, income generation or cultural, political and other domestic activities.

2.3.3. Grain food provision

The environment generally provides the medium for growing the food on which humans are dependent.; this includes the vast range of food products derived from plants, animals and microbes. If the cultivation of plants for food and livestock is to succeed, then natural factors such as fertile soils, adequate soil moisture, rainfall and a rich source of plant and animal species are necessary. With deforestation, these elements diminish too. Deficiencies in some of these elements or attributes can be augmented by technology through the use of fertilizers, irrigation, high-yield seeds and domesticated animals over the short term and for longer periods if managed sustainably.

Pending to discussions in Chapter 4, it is worth here to note that in general poor rainfall in the 2004/05 seasons had a negative impact on crop production in the study area. Overall, the late onset and early cessation of rainfall shortened the agricultural season substantially. The late start, also, deterred some farmers from planting whereas some of the planted seed failed to germinate due to moisture stress. Moreover, the harsh conditions scorched some crops to wilting point beyond recovery. Such occurrences were noted in several parts of Same district. To mention a few, localized food production deficits was experienced in Njoro, Vumari and Ishinde villages in Same district.

Poor grain food crop performance exhibited in the 2004/05-production season and some years back caused the resource weak households to neither manage nor reserve seed from their meagre harvest. Such households could not even afford to buy appreciable seed amounts for planting in 2005/06. Due to limitations of seed availability and unreliable rainfall, farmers cultivated and planted less food crops than in an average year. For instance, low maize yields has consequently made South Pare a net maize importer. Much maize is imported from the Simanjiro and Kiteto districts in the Manyara region (Maghimbi, 2007).

It is evident therefore that environmental degradation in the South Pare highlands has significant consequences for the fuel wood, water and food provisions. In turn, fuel wood, water and food provisions are closely linked to household material welfare. Section 2.4 discusses this link in line with the state of environmental degradation in the South Pare highlands.

2.4. Linking environmental degradation to household material welfare

We identified the following critical constituents which appear to be under serious threat among many households within Pare highlands.

First; the ability to have fuel wood to cook and keep warm: A reliable source of energy is a necessary component of household welfare, as it is required for daily activities

like cooking and keeping warm. The most important source of energy is fuel wood (Monela *et al*., 1999). And, the most energy-consuming task at the household level is cooking. Currently, fuel wood is being consumed more quickly than it can be replaced. South Pare faces enormous energy problems. People have to go longer distances to obtain fuel wood. Wood fuel is becoming scarcer requiring the use of low quality biomass fuels like cow dung, which also causes hazardous indoor pollution; reliance on inefficient biomass energy technologies; and the need to buy wood which was formerly a free commodity (Ndekuka, 1999). Women are the main users and collectors of household fuel and are the most vulnerable to energy problems (Tanzania National Forest Program, 2004).

Second; the ability to have adequate and clean drinking water: Access to adequate and clean drinking water is linked to household welfare, since it affects nutrition through food production, and household members' health through quantity and quality of drinking water. Water scarcity also affects human health through the energy spent in obtaining it. In some mountainous regions of East Africa, for example, household members especially women, might spend up to 27 per cent of their caloric intake in collecting water (Lewis, 1994). The minimum standard set by the United Nations as required by an individual to satisfy human needs is 1,000 m^3 per year (Biggs *et al*., 2004, 13). On daily basis, however, Hinrichsen et al. (1998) suggested a water volume of 20–40 litres per person per day to be the necessary minimum for drinking and cooking needs. This amount rises to between 27 and 200 litres per capita per day if water for bathing and sanitation needs is included. Official estimates in South Pare show that the average rate of daily use for domestic purposes is 16.30 litres per capita per day (*Same District report, 2006/7*). This is below the Hinrichsen et al. (1998)'suggestion of 20-40 litres per person per day excluding bathing and sanitation needs. The average rate of daily water use for domestic purposes of 16.30 litres per day in South Pare falls short even of the survey findings obtained elsewhere in Tanzania. For instance, White et al. (1972) measured water consumption in 19 villages in rural areas of East Africa, at times of the year when water was reasonably abundant in the neighbourhood of the settlement. They found the average rate of daily use for domestic purposes being 18 litres per head. Again later, Drangert (1993) measured water use in six Sukuma villages in Northern Tanzania and reported a range of between 22 and 36 litres per head.

Availability and level of water use is influenced by several factors such as cost, relative wealth of the family, the number of people in the household (amount of water for each member decreases as the number of people increases), the proportion of children and, in the case of piped households, the number of hours of service that make water available, and in the cases of the unpiped householder, the location of the water source (Mujwahuzi, 2002). Water availability is also influenced by environmental factors such as seasonality of rainfall, increased sediment loads in rivers due to deforestation and soil erosion, pollution and overgrazing due to increasing numbers of livestock that use the same water sources as humans, and human population increase (Mujwahuzi, 2002).

The major problems affecting the provision of water services in South Pare and Tanzania as a whole include inadequate funding for construction of new and maintenance of existing water schemes; destruction of water source catchment areas due to deforestation, poor water quality and sanitation services, socio-cultural values, and lack of appropriate working tools (Zaba and Madulu, 1998). As a result, as it stands now, water has to be carried for longer distances and there are long waiting times at the water point to fill water

containers resulting in less water being carried home (Mujwahuzi 2002, 48;). At the national level, despite significant investment in the provision of rural water since 1970s, only about 50 percent of the rural population has access to reliable water supply. The 1978/88-intercensal interval indicates that the absolute number of rural households receiving piped water declined by 22 percent, although the number of households increased by 16 percent over the same time period. The proportion of rural households with piped water has thus declined from 28 percent in 1978 to about 19 percent in 1988. The main causes of this alarming decline have not yet been fully analyzed. However, some of the decline, as physical symptoms signal out in South Pare, is undoubtedly due to drying out of sources probably due to rapid deforestation and climatic change, and maintenance failure of water provision schemes, especially those constructed in the 1970s. Moreover, support in the water sector was provided in a fragmented fashion, and little emphasis was placed on sustainability. This understanding was a basis for the 1991 National Water Policy (URT, 1991). Methods for providing water to the rural people in Tanzania have changed over years and emphasis has been directed to more user-friendly demand- driven programs, with emphasis on local community involvement, especially in the planning and management of the cost of improved water provision.

Third; the ability to be adequately nourished. The ability to be adequately nourished is dependent on two factors; the ability to grow food and the ability to buy food. While the supply of food is critical, economic entitlements that individuals are able to secure, such as income from non-farm labour, are also important (Sen, 1990). There are several measures of the ability to be adequately nourished including that of food (in) security as well as incidence of malnutrition, among others. As subsistence crop production dominates the agricultural economy, the main factor underpinning poor nourishment is inability to grow enough food. Food supply is characterized by declining agricultural production due to inadequate distribution and quantity of rainfall, desertification and lack of economic entitlements. As a result of poor rainfall, planting areas and yield has fallen sharply and maize production is significantly below average (Same district agriculture officer report, 2004/05). In 2004/05, 87 percent of the population was undernourished. Their deficiency was 21 percent for starchy foods and 74 percent for protein foods. The ability to be adequately nourished not only depends on food supply but also on the economic entitlements to buy food. High staple food prices are a problem. Reflecting low supply, maize prices continued to rise in several markets, aggravating the food-security situation of a large number of people (FAO Economic and Social Department 2004). Inappropriate pricing and unreliable cash flow to households continue to aggravate the situation. Although trends in maize price vary across markets, their absolute level is a concern for poor households where poor crop production forces households to depend on markets rather than their own food production (Same district agriculture officer report, 2004/05). The 2004/05 food vulnerable persons in South Pare (87 percent of the total population) had to depend on the market where maize prices of 22,500 – 30,000Tsh per 100 kg exceeded the average maize price level of 15,000–18,000Tsh per 100 kg elsewhere in the country (Same district agriculture officer report, 2004/05).

2.5. Conclusion

This chapter has provided an overview of environmental conditions of the South Pare highlands focusing on the state of environmental degradation and its linkage to household material welfare. The chapter has revealed that the current state of the environment in South Pare is a matter of urgent concern. Natural resources are being depleted, with major developmental and environmental implications. The major environmental problems discussed are land degradation and deforestation whose environmental implications are fuel wood scarcity, lack of accessible good quality water and food provision shortages, which in turn, are directly linked to the household material welfare (standard of living).

Although much information has been gathered in this chapter, much remains to be learnt and empirically analyzed before intervention strategies can be developed. A locally-based integrated assessment, at least in the South Pare highlands, whereby more detailed information on the links between environmental degradation and household welfare and the type of trade-offs and synergies that occur among these links, will provide policymakers in both the Local and Central governments of Tanzania the necessary information to make the necessary interventions.

CHAPTER 3

ENVIRONMENTAL DEGRADATION AND INTRA-HOUSEHOLD LABOUR TIME ALLOCATION

3.1. Introduction

This chapter provides empirical findings and analysis of the results on environmental degradation and household labour patterns, testing Hypothesis 1. We assess whether increased collection and/or grazing time due to environmental degradation alters the time-use patterns of each of the household members, and examine the consumption of environmental products and the allocation of time across tasks and household members. We also assess whether there are gender differences with regard to time reallocation, as is frequently assumed.

The chapter is organized as follows, Section 3.2 presents a literature review of the empirical application of household models on collection of environmental products from the open commons. This is followed by the theoretical framework of agricultural household models in Section 3.3, which is to be applied in the data analysis. We choose and explain the variables that are used in our analysis in sub-Section 3.3.1. We make the theoretical derivation of the household model and propose a general equation for econometric estimation in sub-Section 3.3.2. Section 3.4 presents some descriptive results. Section 3.5 presents the estimation techniques. The estimation results and discussion are offered in Section 3.6. Section 3.7 concludes the chapter.

3.2. Household models on environmental products collection: A review

Rural farm households obtain a wide range of environmental products from community forests and indigenous woodlands for their livelihoods. They typically rely heavily on self-collected environmental products such as fuel wood, water, leaf fodder, cut grass, leaf litter, and a variety of non-timber forest products to meet their subsistence needs (Cooke, 1998). Of all these, firewood, water and grass for animals are the most important environmental products, which are collected mostly from nearby forests and woodlands. A number of studies have highlighted the essential nature of indigenous woodlands to secure the livelihoods of poor households (see Bradley and McNamara, 1993; Arnold, 1995; Grundy *et al.,* 2000). Many environmental products are consumed within households. However, in some households, a proportion of it is traded in the informal sector.

There have been some empirical attempts at assessing the household labour allocation decisions and common property resource use by formally modelling household production systems. Amacher *et al*. (1993) developed a household production model to explore household production and demand for fuel wood and fuel substitutes in two different mid-hill districts of Nepal. The study shows that women and children are significant collectors for those households that rely on community forests for their fuel wood. Moreover, larger families consume more fuel wood. Amacher's study shows that larger landholders collect a considerable amount of residue (leaf litter etc.) from nearby forests, which are later put onto agricultural land to enrich depleted soil. They conclude that

as household income increases, agricultural households may grow a significant portion of fuel wood on their private land while non-agricultural households will convert to substitute fuels and more advanced fuel wood technologies (e.g. stoves) in response to their increasing income (Amacher *et al*., 1993).

Amacher, Hyde and Kanel (1996) formulated and estimated a non-separable household model for fuel wood supply from local common forests using data from Terai and the mid-hill districts of Nepal. The aim of this study was to understand fuel wood purchase versus own collection and to estimate the unobserved shadow wage using a two-step procedure. The study postulates a positive relationship between fuel wood production, livestock holding, and family size. Land ownership reflects an increased opportunity for fuel wood production in the mid-hill districts. Economic measures of fuel wood scarcity such as fuel wood price or the marginal products of labour used in collecting fuel wood are good predictors of local household demand and supply behaviour and, therefore, of pressure on the local resource stock. They conclude that market price, labour opportunities, the availability of substitutes, and measures of access to basic resources are the most reliable predictive variables for fuel wood production and consumption decisions (Amacher, Hyde and Kanel, 1996).

Amacher, Hyde and Kanel (1999) have formulated and estimated a household production model using household data from Nepal's two major populated regions to examine fuel wood consumption and production decisions. They found a significant relationship between labour time (total fuel wood collection time) and fuel wood collection and concluded that fuel wood harvest and fuel wood shipment are labour intensive work. Labour reallocation in order to increase fuel wood collection would cause households to search for labour-saving opportunities in other activities (Amacher, Hyde and Kanel, 1999). Moreover, they observed a positive and significant relationship between land holding and fuel wood collection in their Terai sample. However, their analysis shows a negative relationship between land holding and crop residue consumption. It is also apparent that wealthier households consume fewer crop residues. Based on this observation they conclude that crop residue is an inferior good.

Heltberg, Arndt, and Sekhar (2000) have modelled domestic energy supply and demand in rural India. They examined the links between forest scarcity and household fuel collection in a non-separable household model. Households responded to forest scarcity and increased fuel wood collection time by substituting fuels from private sources for fuel wood from the forests. Households belonging to lower caste and poorer households appeared to consume less private fuels. They found that these households consume significantly more forest fuel wood and spend a longer time collecting it. Livestock ownership was found to increase private energy consumption. Both the number of adult men and the number of women and children had a positive and significant impact on fuel wood collection. They confirm that larger families usually have a greater demand for and more labour available for fuel wood collection.

Cooke (1996), using Nepal Energy and Nutrition Survey data from western Nepal, estimated the empirical links between resource scarcity (fuel wood, fodder, cut grass, drinking water) and household time allocation in order to understand whether households reallocate labour away from their own farm agriculture as fuel wood and fodder become more scarce. These models include cut grass, and leaf fodder shadow price, as well as the shadow prices for water and fuel wood. The yearly cross-sectional results indicate that a

higher fodder shadow price significantly reduces male farm labour input. However, the shadow price for fuel wood is not significant although most values are negative. It appears that scarcity of environmental goods that are important seasonal livestock feeds has more of a negative impact on household farm labour allocation than does scarcity of fuel wood (Cooke, 1996). Household land holdings, household composition, and traditional gender roles in agriculture exert more influence on household agricultural labour allocation decisions than does an increase in the cost of collecting environmental products. Sample households in Cooke's study spent significantly more time collecting environmental products when shadow prices of these forest products were higher.

Linde-Rahr (2001) analyzed the choice of fuel wood collection sources in rural Vietnam using a discrete model with randomly distributed parameters across households in his demand estimation. He estimated the shadow prices and profit for fuel wood collection from different sources (e.g. common property forest, user right plantation forest and open access) based on separate production functions. Household size was directly related to the quantity of fuel wood collected from the common property forest. Moreover, the longer the household has to travel to the source (distance between forest and house) the lower the benefit they reap in terms of fuel wood collection. He found that households are optimizing their choice of fuel wood sources and a relatively strong substitution effect emerges between natural forest and open access areas. However, he suggests that poor households are likely to be more prone to accept some marginal responsibility for open access forest resources.

Heltberg (2001) undertook a study on the determinants and impact of local institutions for common resource management in a protected area in Rajasthan, India. He analysed the factors affecting inter-village differences in management institutions in a logit model. This study also intended to explore the relationship between household socio-economic characteristics and household dependency on common property resource use and thus forest outcomes. Land and livestock holdings are significantly related to grazing on the reserve. This confirms that grazing pressure in absolute terms rises with farm size. However, he observes that fuel wood dependency decreases significantly with land holding indicating substitution toward fuel wood produced on private land.

There is very little empirical evidence on the effects of environmental degradation on intra-household labour allocation in Tanzania. Sano (1996) is one of these few empirical studies. Sano (1996) focused on the relationship between rural poverty and growing environmental degradation in semi-arid parts of Iringa district, Tanzania. His work applied a descriptive approach, not the econometric approach. He concluded that the ongoing environmental degradation, especially in Mazombe and Ismani divisions, proved to be a failure in the adoption of new techniques leading to growing food insecurity in the area.

So far, there is no study available that deals with the effects of environmental degradation on intra-household labour time patterns to collecting scarce environmental products in the rural South Pare highlands. This chapter takes up the challenge.

3.3. Non-separable household decision-making

We apply the non-separable household decision-making model. The non-separable household model incorporates both the consumption and production aspects of household decision-making, and thus captures the essential considerations underlying the allocation of

family time to agricultural work, housework and environmental products collection and/or grazing work (Audra, 1998). This approach provides a theoretical framework for analysis of household behaviour in conditions where non-marketed goods are important, and the economy is subsistence (Bocksteal and McConnell, 1981; Barnum and Squire, 1979).

A subsistence farmer in South Pare faces enormous constraints, for example, endogenous prices due to market imperfections, liquidity problems and time spent on subsistence farming. In this situation, the non-separable household model is preferred, where household resource allocation including environmental product supply and demand, and on-farm and off-farm labour supply is decided simultaneously, rather than recursively (Singh, Squire, and Strauss, 1986; Heltberg *et al*., 2000).

3.3.1. The choice variables

The main processes studied are household labour for both agricultural production and household production, the influence of the environment on household labour, and the effects of household labour on female's and children's labour participation.

The main variables to be used are products used in the household (P_h) and agricultural production (P_a), including environmental products, and time spent on household production (T_h) and agricultural production (T_a), including environmental product collection time. Household size (F), environmental quality (E), and household characteristics (Z) are considered as fixed variables remaining unchanged in the short run. The other choice variables are agricultural outputs (Y_a) and household outputs (Y_h). Most of these variables are stated in vector form incorporating the variables explained below:

Environmental degradation (E)

Environmental degradation, E, refers to the environmental status where the particular household resides. It is categorized into three states: namely, non-degraded, medium and severely-degraded conditions. The category is specified based on vegetation cover, rainfall, soil type, humidity, and soil erosion. In most socio-economic surveys, the bases of categorization are represented by ordinal scales such as good/bad, high/medium/low, etc. (Lomperis, 1991; Yanaihara, 1993; Flaherty and Jenglalern, 1995)[14]. Information on this variable obtained from the village, ward and government officials in the area of research shows that the non-degraded is the upland plateau zone, the medium-degraded is the middle-plateau zone and the severely-degraded is the lowland-plateau zone. Environmental degradation is expected to increase household labour time in the household and agricultural production function equations since more time is needed to collect fuel wood, water and out-door grazing.

Products (P_{aM}, P_{hM}, P_a, P_h)

Market products used for household and agricultural production processes include capital goods, such as a stove, land, hand hoes and/or tractors, various inputs used in the production of a particular crop, such as seeds, fertilizers, insecticides, and transportation, all categorized either as market-priced agricultural inputs (P_{aM}),household market-priced

[14] Quoted in Koffi-Tessio, (2004)

inputs (P_{hM}), or environmental products used for agricultural or household purposes (P_a, P_h).

Environmental products refer to various products that households collect from the environment. The ones that are considered in this study are fuel wood, P_f, grass, P_g, and water, P_w. Most of the households that keep animals do not practice in-door animal keeping. So, the study considers the time spent on out-door grazing as a proxy for cut-grass demand. Firewood, a woody biomass, and part of fuel wood (the other part is charcoal, see Johansen, 1999*)* includes freshly cut wood, dead branches, twigs and plant residue (Bjracharya, 1979). Grass refers to all non-woody herbaceous plants used for animal feeding in an out-grazing practice. It includes members of the grass and sedge families, a variety of legumes and other broad leaf plants (Jefferson, 1983). The environmental products are collected at the homestead, *kaya*, the fields, *shamba,* fallow-land, *pori***,** and forest, *msitu. Kaya* consists of the family's house and the garden. *Shambas* are the fields owned by the family for cultivation, which might have vegetation looking like forest. *Pori* are open public spaces found scattered all over the village or ward in which various tree species are found. The areas called *msitu* are the areas where the vegetation is dense with a variety of different species. The *msitu* is owned by the government but the locals are permitted to collect its products. Water collection and out-door grazing generally are done on a daily basis. Firewood may be collected and stored. The forest (*msitu*) is usually at a distance reached by small rough paths. Neighbouring households and relatives usually go together to fetch firewood but each is collecting for the household he/she comes from. They go together for security reasons, and especially women perceive the forest as a fearsome place connected to myths and traditional cosmology (Bildsten, 2002). Sometimes, women would like to go together because they can talk more freely than around the house, joking and gossiping (Bildsten, 2002).

Time inputs (T_a, T_h)

Time inputs include the time spent by each of the household members on both agricultural (T_a) and household (T_h) production processes, including time spent collecting environmental resources (fuel wood, T_f, water, T_w, and grass/grazing, T_g). Time inputs are explained by household demographic factors (age, household size, adult literacy rate, gender and ethnicity), total household income, environmental product price, livestock units, and environmental quality.

Agricultural and household outputs (Y_a, Y_h)

Agricultural output (Y_a) is the weight in kilograms per acre for each particular crop produced. Household output (Y_h) refers to home-produced consumption goods such as meals (Y_m) in the household.

Household income (I)

This variable refers to total household income earnings from whatever source including farm, off-farm labour together with remittance income which may range from negative to positive depending on whether the household is a net recipient or giver of transfers. I is measured in Tanzanian shillings per household per year. It is an explanatory variable in both the environmental product demand equation and the environmental product collection time equation. The higher the income, the higher the ability to purchase alternatives such as

kerosene in the market place and the lower the demand for environmental products and thus decreasing collection time. So also, the lower the income, the lower the ability to purchase alternatives in the market place and the higher the demand for environmental products and thus increasing collection time.

Household characteristics (Z)

Household specific factors include each member's age, age squared[15], gender, adult literacy rate and ethnicity. These factors influence, inter alia, time spent by the household on household and agricultural production processes, including environmental product collection. Age is measured as years after birth. Gender is the condition of being male or female. Ethnicity is a particular socio-traditional tribe that a particular household belongs to. There are mainly four ethnic groups in the area of research; namely, Chagga, Sambaa, Mbugu and Pare. From all of these, the Pare are dominant. The Pare are agro-pastoralists practicing stock breeding and agriculture. These ethnic groups differ in social norms (e.g. on how they value the status of the woman in the household) that might affect intra-household time allocation patterns apart from the status of the environment they reside. In all equations estimated in this study, household characteristics are taken as independent variables.

Embodied in the household characteristics is the household size. Household size is defined as the total number of people who live in the same dwelling and share at least one meal a day (Lind, 2000). It is an explanatory variable in the household agricultural and household production functions. It is expected to increase total and per acre labour input and thus influencing agricultural output.

3.3.2. The theoretical model

We construct the theoretical model based on a conventional utility maximizing household, which derives the highest level of utility by consuming various goods. We consider a representative farm household, which is assumed to maximize its utility function dependent on consumption of household goods Y_h and other goods Y_a. For simplicity and illustration purposes, we consider household goods to refer to home-produced meals (Y_m). Household utility is assumed to be conditional on a vector of fixed household characteristics Z, including gender and age of the household members and the household size, which may affect household preference.

$$U = U(Y_m, Y_a, Z) \qquad (1)$$

Household goods Y_m are produced with environmental product inputs i.e. fuel wood (indicated by subscript f), P_f, which is mostly collected from the common natural forest. Households may also purchase fuel wood (indicated by subscript p after f), P_{fp}, and some households may sell fuel wood in the local market (indicated by subscript s after f), P_{fs}. The sold amount of fuel wood is deducted from the production function. Meals are produced with agricultural grain grown on-farm, Y_a such as maize, millet or rice. Households may purchase agricultural grain (indicated by subscript p), Y_{ap}, to produce meals. Some households also sell agricultural products (indicated by subscript s), Y_{as}, and

[15] Included to represent non-linear age effects

this amount is deducted from the production function. These physical inputs are combined with household labour time inputs, T_m , to produce cooked meals. The production of home-produced meals is also a function of the vector of household capital goods such as stove technology applied, P_{hM} . The production constraints for meals can be written as

$$Y_m = Y_m\{T_m, (P_f + P_{fp} - P_{fs}), (Y_a + Y_{ap} - Y_{as}), P_{hM}\} \quad (2)$$

Agricultural grain, Y_a , is produced on-farm, which is a function of household labour time, T_a , land, P_{aM} , and livestock units, K , which contribute to agricultural production by providing manure. For many households animal dung is the only source of fertilizer. So the agricultural production constraint is given by

$$Y_a = Y_a\{T_a, P_{aM}, K\} \quad (3)$$

Though households collect a variety of products from the commons, few products have a significant impact on household time allocation patterns. It was observed that households mainly collect two different environmental products from the commons, that is, fuel wood and water. So, only two production functions are defined in this model. Fuel wood and water production technology are given by continuous quasi-concave production functions that describe the collection of environmental products from common property forests. The variables T_f and T_w denote labour times used in environmental product collection, respectively. It is hypothesized that environmental product collection is also conditional on a vector of fixed household characteristics, Z , (i.e., land holding size, ethnicity, gender, education, access condition, distance between house and the common forest, technology of harvesting etc.). Since the vector of household characteristics, Z , differs across households, marginal productivity of labour time will also differ across households. Production technology for fuel wood, P_f , and water, P_w , is given by

$$P_f = P_f(T_f, Z) \quad (4a)$$

$$P_w = P_w(T_w, Z) \quad (4b)$$

Animal related goods are produced using household labour time for out-door grazing in the common property forest where the grass is. The households keep animals mainly for milk, meat and manure. The one considered in this model is manure (fertilizer). So in this model the animal production function is treated merely as a technology that converts labour time and environmental products (grass) to produce manure. Other functions of animals are not considered in this model. Animal production can be described as;

$$K = K\{P_{ag}(T_g, Z)\} \quad (5)$$

The representative households maximize their utility function subject to a set of budget and time constraints. The households' time constraint is given by

$$T = T_f + T_w + T_m + T_g + T_a \quad (6)$$

The budget constraint is:

$$p_a Y_a + p_f P_{fp} + p_w P_{wp} + p_a P_{ap} = L_o W_o + p_f P_{fs} + p_w P_{ws} + p_a Y_{as} + I \qquad (7)$$

The variables p_a, p_f and p_w refer to the market price of agricultural grains, fuel wood and water, respectively. L_o, W_o and I refer to off-farm labour time, off-farm wage and household income, respectively. The problem for the subsistence farm household is:
To maximize utility function (1), subject to

(a) production constraints (2-5)
(b) time constraints (6) , and
(c) budget constraints (7).

The Lagrangian for an internal solution to the problem is:

$$L = U\{Y_a, Y_m[T_m, (P_f(T_f, Z) + P_{fp} - P_{fs})), (Y_a(T_a, P_{aM}, K\{P_{ag}(T_g, Z)\}, P_{ag}(T_g, Z)\} + Y_{ap} - Y_{as})); P_{hM}]; F\} - \lambda\{T_f + T_w + T_m + T_g + T_a\} - \mu\{L_o W_o + p_f P_{fs} + p_w P_{ws} + p_a Y_{as} + I - p_a Y_a - p_{fP_{fp}} - p_w P_{wp} - p_a P_{ap}\} \qquad (8)$$

The endogenous variables in this model are $T_f, T_w, T_g, T_a, T_m, P_{fp}, P_{fs}, Y_{ap}, Y_{as}$ and Y_a. Maximizing the Lagrangian with respect to these variables yields the following first-order conditions:

$$\frac{\partial L}{\partial T_f} = \frac{\partial U}{\partial Y_m}\frac{\partial Y_m}{\partial P_f}\frac{\partial P_f(.)}{\partial T_f} - \lambda = 0 \qquad (8a)$$

$$\frac{\partial L}{\partial T_w} = \frac{\partial U}{\partial Y_m}\frac{\partial Y_m}{\partial Y_a}\frac{\partial Y_a}{\partial K}\frac{\partial K}{\partial P_w}\frac{\partial P_w(.)}{\partial T_w} - \lambda = 0 \qquad (8b)$$

$$\frac{\partial L}{\partial T_a} = \frac{\partial U}{\partial Y_m}\frac{\partial Y_m}{\partial Y_a}\frac{\partial Y_a}{\partial K}\frac{\partial K}{\partial P_{ag}}\frac{\partial P_{ag}(.)}{\partial T_g} - \lambda = 0 \qquad (8c)$$

$$\frac{\partial L}{\partial T_a} = \frac{\partial U}{\partial Y_m}\frac{\partial Y_m}{\partial Y_a}\frac{\partial Y_a}{\partial T_a} - \lambda = 0 \qquad (8d)$$

$$\frac{\partial L}{\partial T_m} = \frac{\partial U}{\partial Y_m}\frac{\partial Y_m}{\partial T_m} - \lambda = 0 \qquad (8e)$$

$$\frac{\partial L}{\partial P_{fp}} = \mu p_f \qquad (8f)$$

$$\frac{\partial L}{\partial P_{fs}} = -\mu p_f \qquad (8g)$$

$$\frac{\partial L}{\partial Y_{ap}} = \mu p_{ap} \qquad (8h)$$

$$\frac{\partial L}{\partial Y_{as}} = -\mu p_{as} \qquad (8i)$$

$$\frac{\partial L}{\partial y_A} = \frac{\partial u}{\partial Y_a} + \mu p_a = 0 \qquad (8j)$$

Equations (8a–8e) give the conditions for optimal labour allocation by the farm household, which stated that in equilibrium the ratios of the marginal products of various

activities are equalized with the relevant price ratios. Equations (8a–8c) show that the household allocates labour time for various environmental product collection and/or grazing activities until the marginal product of labour time used in collection and/or grazing activities equals the endogenous value of household labour time. In other words, 8a-8c first-order conditions indicate that a household equates the marginal utility of environmental product collection and/or grazing to the shadow price of collecting these products, λ. The first-order conditions (8f- 8g) show that those households that purchase and sell fuel wood face a market price. Differentiating the right hand side of equation 8a – 8c $[\frac{\partial P_f(.)}{\partial T_f} - \lambda; \frac{\partial P_w(.)}{\partial T_w} - \lambda; \frac{\partial P_{ag}(.)}{\partial T_g} - \lambda]$ with respect to the exogenous variables, increases the marginal product (positive partial derivatives) of household labour time (which shift upwards) from gathering activity. This is due to the fact that households allocate more labour time to harvest environmental products to meet their increasing demand for both agricultural and household inputs. We test whether, for our sample in South Pare, households allocate much labour time to harvest environmental products to meet their increasing demand for both agricultural and household inputs. We take into consideration the environmental conditions where the sample households live. We introduce, therefore, the environmental quality variable, E, capturing non-degraded, medium-degraded and severely-degraded environmental conditions. The endogenous variables of interest in our model are environmental product collection and/or grazing time variables, T_f, T_w, T_g, in equations 8a to 8c.

Taking into account the effects of environmental quality, *E*, average weekly household income, *I*, weekly consumption of meal-related environmental products in kilograms/litres (fuel wood, P_f, and water, P_w), and agricultural-related environmental products (grass for animals, P_g) as inputs in agricultural, Y_a, and household production of home-produced meals, Y_m, in each household, and fixed household characteristics, Z, including household size, gender, and age of the household members, we propose the following equation for family time allocation:

$$T_j = t\left(E, Z, P_f, P_w, I\right) = X\beta + u \qquad (9)$$

where T_j equals the hours per week each household member spends on fetching environmental products nand/or grazing (j = 1, 2, 3), X, the observation matrix, β a vector of coefficients, and *u* an independently distributed normal error term. Household consumption of environmental products and household income are both measured on a weekly basis. We expect the coefficients of environmental degradation, *E*, to be positive because environmental degradation is expected to increase household labour time in harvesting scarce environmental products. We expect negative coefficients for household income and education levels of the household members. The income coefficient is expected to be negative because we perceive fuel wood collection, water fetching and/or out-door grazing as inferior goods (Amacher, Hyde and Kanel, 1999). Education may be somehow associated with income. The higher the education the higher the probability of securing a well-paid job which in turn generates high income at which untreated open-access water, fuel wood and grass are considered as inferior goods. In addition, an individual with low education usually is endowed with less skills enabling easy collection and/or grazing. On the other hand, a relatively learned individual is endowed with the ability to search for alternatives that would ultimately reduce the collection and/or grazing burden. Furthermore, we expect non-negative coefficients for the amount of environmental products. Rural

subsistence households simply do not have alternative 'options' regarding fuel wood as a source of energy and water except for collecting them from open commons or go without. Demand, at this basic level, is almost perfectly inelastic. The cost (in terms of gathering time), therefore, does not materially affect consumption quantity (Waggener, 1977).

3.4. Descriptive results

The survey households are composed of couples and primary school-age children. This strategy enables the analysis of the difference in labour allocation between four household member categories, namely, wives, husbands, and school-age boys and girls. Such labour allocation is referred to as intra-household labour allocation.

Table 3.1 shows the frequency table of the number of survey households differentiated according to the three environmental conditions.

Table 3.1. Number of households by environmental condition

Environmental condition	Frequency	Percentage
Non-degraded	90	29.9
Medium-degraded	91	30.2
Severely-degraded	120	39.9
Total , N	301	100

Table 3.2. Distribution of time per week by environmental condition and by household member

	Non-degraded		**Medium-degraded**		**Severely-degraded**	
Husband	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Water fetching hours	2.02	4.95	2.15	7.19	2.88	6.98
Fuel wood collection hours	0.96	2.14	0.34	1.29	1.71	3.70
Grazing hours	10.98	12.53	35.53	28.50	32.43	25.78
Agriculture working hours	36.80	10.69	41.87	12.03	37.60	11.56
Household chores hours[a]	6.56	10.69	13.99	18.51	12.59	14.76
Formal employment hours[b]	3.11	10.77	0.44	4.19	2.33	9.41
Leisure hours[c]	107.57	19.75	73.69	40.94	78.46	30.53
Wife						
Water fetching hours	13.21	10.51	11.22	12.93	15.92	9.98
Fuel wood collection hours	11.16	6.72	6.95	4.07	14.26	6.03
Grazing hours	1.42	5.74	1.97	8.47	7.20	14.90
Agriculture working hours	38.33	8.08	39.30	10.71	36.22	11.37
Household chores hours[a]	34.22	24.86	47.73	27.18	52.81	24.54
Formal employment hours[b]	1.33	7.22	0.00	0.00	1.33	7.21
Leisure hours[c]	68.32	29.15	60.83	36.60	40.26	32.65
Schoolboy						
Water fetching hours	5.04	2.54	6.16	4.49	11.24	8.71
Fuel wood collection hours	3.38	1.67	4.12	2.99	7.50	5.80
Grazing hours	2.35	2.26	3.60	3.40	6.13	6.77
Agriculture working hours	8.01	5.67	7.54	5.39	11.77	6.73
Household chores hours[a]	4.19	2.45	3.94	2.44	7.09	4.38
Formal employment hours[b]	n/a	n/a	n/a	n/a	n/a	n/a
Leisure hours[c]	80.09	8.04	78.35	24.80	55.66	29.16
School hours[d]	60.60	3.31	60.34	12.35	61.33	4.62

Schoolgirl						
Water fetching hours	4.93	2.18	6.02	3.78	8.74	6.79
Fuel wood collection hours	3.30	1.43	4.02	2.51	5.84	4.51
Grazing hours	1.90	2.02	2.61	2.83	3.90	4.80
Agriculture working hours	9.23	5.18	7.51	5.92	9.35	7.13
Household chores hours[a]	5.19	2.53	5.58	4.03	7.08	3.85
Formal employment hours[b]	n/a	n/a	n/a	n/a	n/a	n/a
Leisure hours[c]	78.27	10.58	74.94	21.42	66.11	26.65
School hours[d]	59.88	5.56	61.94	9.27	60.04	10.00

Legend: n/a – not applicable; Std. Dev. – Standard Deviation

a. Household chores hours are the sum of the average hours each family member in the above three categories spend per week on cleaning, cooking and childcare

b. Formal employment hours are the sum of the average hours a family member spends per week in the job of his/her employer be it the Government, Parastatal or private sector.

c. Leisure hours are average hours available per week for ease and relaxation free from responsibilities, including sleep

d. School hours are average hours per week dedicated to education. This includes time spent on walking to and from school, time in school and time spent on school homework plus private studies at home.

Table 3.2 shows that generally, on average, males spent less time than women on water fetching, fuel wood collection and household activities, but they worked more on grazing. Both males and females worked on the farms almost equal amounts of time with males taking a lead of an average of 1 to 2 hours more. However, because the household chores were entirely the burden of females, on average, males had more leisure hours than females in all environmental conditions. Household members residing in severely-degraded environmental conditions spent more time fetching water, collecting fuel wood and grazing and thus having relatively little time for leisure.

Because of our interest in examining the influence of time-use in collecting environmental products, we take a further look on each of these products, namely, fuel wood, water, and grazing taking into account the environmental conditions.

3.4.1. Fuel wood

Table 3.3 shows the mean hours the family members spent daily fetching fuel wood by environmental condition and village. Women residing in the villages that have severely-degraded environmental conditions like *Ishinde, Njoro, Mgandu* and *Mvure-kongei* spent on average half of the daytime fetching fuel wood. The next most affected group was that of the school-age children. It is only in *Ishinde* village that a significant cooperation between wives, husbands and school-age children was reported thus marginally reducing the average number of hours the women spent daily fetching fuel wood to an average of 5.43 hours a day. In households with zero average contribution of the husbands, school-age children compensated the gap by spending more hours to help their mothers fetching fuel wood. The overall mean hours that women spent daily collecting fuel wood in all ten surveyed villages was 3.86; for schoolchildren it was 2.46; while that of men was 0.64 (see Table 3.4). That is, women and schoolchildren spent an overall average of one-third of the daytime fetching fuel wood. Women went out to fetch fuel wood on average 3 days in a week while men went out on average 0.35 days in a week. Table 3.3 shows that both women and schoolchildren shared the burden almost equally in medium-degraded environmental conditions. Surprisingly, Table 3.3 shows that women in non-degraded environmental conditions spent comparatively more hours on average than women in the middle-degraded conditions fetching fuel wood. In normal circumstances, one would expect the opposite! The reason for this was the successful ongoing afforestation program

accompanied with effective by-laws that forbid the villagers to harvest the newly flourishing-land cover in the neighbourhoods for domestic purposes (see Persha, 2003; Same district council, 2006). The villagers collected only little dead wood from these nearby forests and the prohibitions against cutting live indigenous trees was the main reason for the fuel wood shortage in these presently non-degraded villages.

Table 3.3. The mean hours spent daily fetching fuel wood by environmental condition, village, and household member

	Non-degraded (the upland plateau zone)			Medium-degraded (the middle plateau zone)			Severely-degraded (the lowland zone)			
	Gwanga	Gonzanja	Kirangare	Mgwasi	Vumari	Kizungo	Ishinde	Njoro	Mgandu	Mvure-kongei
Wife	2.76	3.93	2.48	2.26	1.66	2.41	5.43	5.77	6.00	6.00
Husband	0.20	0.00	0.91	0.00	0.52	0.00	4.23	0.57	0.00	0.00
Child	2.07	1.63	1.20	2.68	1.26	2.12	2.13	2.16	3.97	4.87

Table 3.4. Distribution of hours and days in a week spent fetching fuel wood for household consumption

	N	Mean	Std. Dev.
hours a day wife spent	301	3.86	2.02
hours a day husband spent	301	0.64	1.52
hours a day schoolchild spent	301	2.46	2.06
days a week wife spent	301	3.06	1.27
days a week husband spent	301	0.35	0.82

3.4.2. Water

Table 3.5 shows the mean hours wife, husband and schoolchild each spent daily fetching water in ten surveyed villages. The number of hours reported included the time spent waiting in queue.

Table 3.5. The mean hours spent daily fetching water by environmental condition, village, and household member

	Not-degraded (the upland plateau zone)			Medium-degraded (the middle plateau zone)			Severely-degraded (the lowland zone)			
	Gwanga	Gonzanja	Kirangare	Mgwasi	Vumari	Kizungo	Ishinde	Njoro	Mgandu	Mvure-kongei
Wife	0.80	3.09	2.19	2.36	1.06	2.45	5.87	3.84	1.73	2.01
Husband	0.05	0.03	0.85	0.07	0.20	0.89	4.57	0.67	0.00	0.00
Child	0.89	0.71	0.53	1.15	0.55	0.91	0.92	1.12	1.70	2.09

Table 3.6. Distribution of hours and days in a week spent on water- fetching for household consumption.

	N	Mean	Std. Dev.
hours a day wife spent	301	2.54	2.08
hours a day husband spent	301	0.73	1.74
hours a day schoolchild spent	301	1.06	0.88
days a week wife spent	301	5.60	1.92
days a week husband spent	301	0.80	1.92

In all surveyed villages, except Gwanga and Mvure-kongei, women took the lead in spending more time on average than men and schoolchildren in fetching water. Schoolchildren were close associates of their mothers in the exercise. In the households residing in Mgandu and Mvure-kongei villages where husbands seem not to involve themselves in the water-fetching activity, both women and schoolchildren spent an average of almost two hours a day each in water collection. The principal water source in the Gwanga village is a seasonal spring. All the sample households use spring water. However, according to the village executive officer[16], the spring dries up during the dry season and villagers have to dig wells in the dry spring. Since the spring runs through the village, the distance to the water source from the sample households is 1 kilometre or less. Accordingly, the travel time to the water source is relatively short, an average of less than one hour, compared with other sample villages. The overall mean hours women spent daily in water fetching in all ten surveyed villages was 2.54; for school-age children it was 1.06; while that of men was 0.73 (see Table 3.6). Women went out to fetch water on average 5.60 days a week while men went out on average 0.80 days a week.

Springs form one of the major sources of household water in the non-degraded (upland) plateau zone. The survey data show both piped water and springs are almost equally relied on by the households residing in the non-degraded environmental conditions as the major sources of water for domestic consumption. 42. 2 percent of the survey households in the non-degraded environmental conditions (that is, upland plateau zone) obtained water from pipes while 48.9 percent of the households in the same zone retrieved domestic water from springs (see Table 3.7). The recorded percentage of households in the non-degraded environmental conditions that obtained water from springs is the highest in comparison with other households located in the medium and severely-degraded areas. The percentages for these areas were 39.6 and 20.8, respectively. This means, the spring waters slowly dry up as they flow down hill to the lowland. With poor vegetation cover along the steep and mid-sloped areas, uncontrolled run-off concentrates in small channels or rills leading to the formation of gullies and seasonal streams. 25 percent of the households in the severely-degraded (lowland) areas relied on these streams and a common piped reservoir (23.3 percent) as the major sources of household water. However, this common piped reservoir runs to a trickle and stops altogether during the dry season. Water stored in dams and fetched from boreholes (ground water) is thus increasingly being used to meet domestic requirements. About 13.3 percent and 17.5 percent of the interviewed households fetched water from the dams and boreholes, respectively. There are neither dams on the upland

[16] The Gwanga village Executive Officer at the time of field research in this village (Oct./Nov. 2006) was Mr. Niwael Naftal.

(non-degraded) nor middle land (medium-degraded). Thus, households did not retrieve water from this source. The number of boreholes, too, is insignificant in non-degraded and medium-degraded environmental conditions. It was available to only 2.2 and 4.4 percent of the survey households, respectively.

Table 3.7. Household sources of water in the South Pare highlands and use percentages

Environmental Quality	Household water sources										Total # hslds
	Piped water		Boreholes		Streams		Dams		Springs		
	# hslds	%	# hslds	%	# hslds	%	# hslds	%	# hslds	%	
Non-degraded	38	42.2	2	2.2	6	6.7	0	0	44	48.9	90
Medium-degraded	44	48.4	4	4.4	7	7.7	0	0	36	39.6	91
Severely-degraded	28	23.3	21	17.5	30	25	16	13.3	25	20.8	120

Legend: *# - number; hslds – households*

3.4.3. Grazing

Table 3.8 shows the mean hours family members spent weekly on grazing by environmental condition and village. It is evident that grazing was predominantly the work of husbands. Observation in the study area shows that besides the husbands, the grazing work was carried out by other adult male members in the households as well. They grazed cattle around the village. Calves were taken care of by children around their homesteads. Usually during the dry season, after crop harvest, the crop fields turned into grazing lands as well. Husbands residing in villages in both medium and severely-degraded environmental conditions spent more time than husbands in the non-degraded conditions. Observations show that none of the wives in 5 of the 10 surveyed villages participated in the grazing activity. However, schoolchildren did participate in grazing in collaboration with their male parents, though the number of hours they spent in the work per week was small.

Table 3.8. The mean hours spent weekly on grazing by environmental condition and village

	Non- degraded (the upland plateau zone)			Medium-degraded (the middle plateau zone)			Severely-degraded (the lowland zone)			
	Gwanga	Gonzanja	Kirangare	Mgwasi	Vumari	Kizungo	Ishinde	Njoro	Mgandu	Mvure-kongei
Wife	2.03	2.23	0.00	0.00	5.98	0.00	22.03	6.77	0.00	0.00
Husband	14.99	13.77	4.20	42.93	23.53	39.97	37.77	17.27	32.43	42.27
Child	3.60	2.27	0.43	4.63	1.70	2.87	3.93	2.27	5.80	8.80

Overall grazing mean hours in Table 3.2 show that husbands in the medium-degraded environmental conditions spent more hours than husbands in other environmental conditions. The main reason for the practice could be the lack of grazing land on the hills that forced the agro-pastoralists to take their herds of cattle downhill to the lowlands for pastures in the open commons. The nature of the landscape and slow movements of cattle

up and down the hills, contributed to the long time taken in out-door grazing. Agro-pastoralists in the non-degraded environments did not take their livestock to the lowlands for grazing. This explains why they did not spend much time. Moreover, most of the livestock keepers in the non-degraded environments practiced indoor grazing with limited herds of cattle that fed around the homesteads on available grass and crop residues.

3.5. Estimation technique

We realize that the outcome variable T_j is only observed if some criterion is met. For instance, the household member may spend time on grazing if the household keeps cattle; the husband may fetch water and fuel wood if he feels like; the wife may take cattle for grazing if need arises (e.g., the husband is sick or the herd of cattle is large); etc. Thus T_j is observed only if a condition z is met. We use the Heckman two-step selection model to avoid biased results in our estimations (Heckman, 1979). In the first step, a dichotomous variable z determines whether or not T_j is observed, T_j being observed only if $z = 1$ (and we estimate a linear probit model with independent variables w , coefficients α, and an error term, ε). In the second step, we model the expected values of T_j, conditional on its being observed. So, we observe z, a dummy variable, which is a realization of an unobserved variable z*, having a normally distributed, independent error, ε, with a mean zero and a constant variance σ_ε^2. For values of $z = 1$, we observe T_j, (and model that with a matrix of independent observations, X, and a vector of coefficients, β explained in equation 9), which has a normally distributed, independent error, u, with a mean zero and a constant variance σ_u^2. The two error terms are assumed to have a correlation ρ. The joint distribution of u and ε is assumed bivariate normal. This is briefly explained in the following equations:

$$\left.\begin{array}{l} z_i^* = w'_i\,\alpha + \varepsilon_i \\ z_i = 0, if, z_i^* \le 0; \\ z_i = 1, if, z_i^* > 0 \end{array}\right\} \text{Selection Equation} \qquad (10)$$

$$\left.\begin{array}{l} T_j \;\; = x'_i\,\beta + u_i, \quad if, z_i = 1 \\ T_j \, not\ observed\ if\ \ z_i = 0 \end{array}\right\} \text{Outcome Equation} \qquad (11)$$

We first estimate a probit model for the probability that $z = 1$. That is, $prob(z_i = 1) = \Phi(w'_i\,\alpha)$, with Φ being the cumulative standard normal distribution function. This model is estimated with all of our observations using a set of covariates w and yielding a coefficient vector α. The second step is to estimate the expected value of the outcome variable, T_j, conditional on $z = 1$ and observations X.

$$E(T_j \mid z = 1, x_i) = x'_i\,\beta + E(u_i \mid z_i = 1).$$

This yields a coefficient vector β. Skipping ahead a few steps, we end up with equation (12).

$$x'_i \beta + E(u_i \mid \varepsilon_i > w'_i \alpha) \tag{12}$$

To evaluate the conditional expectation of u in equation (12) we make use of the fact that the expected value of one of the variables in a bivariate distribution (in this case u) censored with respect to the value of the other variable (in this case ε) is given by equation (13).

$$E(u_i \mid \varepsilon_i > w'_i \alpha) = \rho \sigma_\varepsilon \sigma_u \frac{\phi(w'_i \alpha)}{\Phi(w'_i \alpha)} \tag{13}$$

Inserting equation (13) into equation (12) we obtain equation (14), which gives the expected value of T_j given that $z = 1$. This is exactly what we are looking for in our outcome equation.

$$E(T_j \mid z = 1, x'_i) = x'_i \beta + \rho \sigma_\varepsilon \sigma_u \frac{\phi(w'_i \alpha)}{\Phi(w'_i \alpha)} \tag{14}$$

To estimate equation (14), we first take the probit results and, for the subsample for which $z = 1$, we compute the ratio of ϕ and Φ, the inverse mills ratio, symbolized by λ. Then, for this same subsample, we use OLS to regress T_j on X and λ. This will yield estimates of the familiar vector of coefficients (β), and of θ, which is the covariance of u and ε. Equation (15) shows that the resulting estimates of β, in general, will be biased if λ has been omitted. The problem of sample selection bias thus becomes equivalent to a misspecification problem arising through the omission of a regressor variable.

$$E(T_j \mid z = 1, x_i) = x'_i \hat{\beta} + \Theta \hat{\lambda}_i \tag{15}$$

There are only two cases where bias will not be a problem: First, if $\rho = 0$, second, if the correlation between λ, and any X variable equals zero.[17]

[17] Look at this likelihood function for illustration:

$$\underbrace{L = \sum_0 \log(1 - \Phi_i) + \sum_1 \log \Phi\left[\frac{w'_i \alpha + \rho\left(\frac{t_i - x'\beta}{\sigma_u}\right)}{(1-\rho^2)^{\frac{1}{2}}}\right]}_{\text{if } \rho=0, \quad \text{Probit}} + \underbrace{\sum_1 -\tfrac{1}{2}\left[\log\left(2\pi\sigma_u{}^2\right)\right] + \left[\frac{(T_j - \beta' X_i)}{\sigma_u}\right]^2}_{OLS}$$

$$L = \sum_0 \log(1 - \Phi_i) + \sum_1 \log \Phi(w'_i \alpha) \qquad L = \sum_1 -\tfrac{1}{2}\left[\log\left(2\pi\sigma_u{}^2\right)\right] + \left[\frac{(T_j - \beta X_i)}{\sigma_u}\right]^2$$

If $\rho = 0$, the likelihood function can be split into two parts: a probit for the probability of being selected and an OLS regression for the expected value of T in the selected subsample. Because these two parts share no common parameters, they can be estimated separately. This shows that if there is no residual correlation between ε and u_i the simple OLS approach is all we need to explain *T*. The fact, therefore, is not that observations on *T* are only available for a selected sample that causes the difficulty; rather, it is that the selection is not random with respect to *T*.

3.6. Estimation results and discussion

Environmental quality, some household/individual characteristics like ethnicity, education levels, and occupations are specified in dummy variables.

Heckman two-step estimates are presented in Tables 3.9a, 3.9b, and 3.9c. A general overview of the results clearly proves that environmental products collection and/or grazing activities in South Pare are gender biased with husbands specializing in grazing while wives and children were mainly fetching water and fuel wood. Just a small percentage of husbands in the survey households engaged themselves in water and fuel wood fetching (i.e. 20.4 percent and 17.9 percent, respectively. See Legend, Table 3.9a); and also very few wives took animals for out-grazing (i.e., 23.7 percent of the wives in the survey households. See Legend, Table 3.9b). Schoolchildren, whose estimation results are presented in Table 3.9c, participated in all collection and grazing activities. However, most of the schoolchildren participated in water and fuel wood collection activities and few engaged in grazing. 94.7 percent of survey schoolchildren participated in fuel wood and water fetching while only 60 percent helped their parents in grazing (See Legend, Table 3.9c). Considering the gender of the schoolchildren, 95.4 percent of the survey schoolboys participated in both fuel wood and water fetching activities while only 65.1 percent engaged in grazing. 94 percent of the schoolgirls fetched fuel wood and water while 57.7 percent helped grazing.

The model performed satisfactorily in explaining both gender-specific and non-gender specific activities. That is, while the model performed satisfactorily for husbands in explaining fuel wood and water fetching, it also performed well on grazing. Also the model worked satisfactorily for wives and children on grazing, and meanwhile performed well on fuel wood and water fetching activities. Neither ρ nor λ were completely *zero* in all two-step estimates indicating selection bias and therefore the application of the Heckman model was appropriate. The estimated ρ was small for gender-specific activities such as grazing for husbands ($\rho = 0.181$), water and fuel wood fetching for wives (*rho* $\rho = -0.655$ *and* $\rho = 0.215$ *respectively*) confirming the appropriateness of the model. The estimated value of ρ for non-gender specific activities was comparatively larger but still at acceptable level and we do not question the appropriateness of these sub-models. For instance, grazing estimates for wives gave $\rho = 0.755$ and water fetching estimates for husbands gave $\rho = 0.572$ which are both econometrically acceptable.

Most importantly, Tables 3.9a, 3.9b, and 3.9c show that environmental products collection and/or grazing time by the household members is, almost in all groups and in accordance with gender-biased activity, significantly influenced by the environmental conditions. In the non-degraded environment, as compared with the severely-degraded environment, husbands spent more time on grazing; wives spent more time on fuel wood collection; and schoolchildren spent more time in all collection and grazing activities. The estimates regarding gender of schoolchildren reveals that being schoolboys significantly decreased the probability of spending more time on fuel wood and water fetching because these were predominantly female jobs (see Table 3.9c, selection equation). However, being schoolboys significantly increased the time spent on a male job of grazing (see Table 3.9c, outcome equation).

The parameter estimates in the outcome equations, for severely-degraded environmental conditions in all collection and/or grazing activities, as per gender-biased work, were positive and statistically significant (see Table 3.9a, 3.9b, and 3.9c). This was primarily due to resource scarcity, indicating that households allocated more labour time to

harvesting environmental products to meet their demand for both agricultural and household production inputs. The results also were supported by the findings by Amacher *et al.* (1993) who asserted that in Nepal women and children are significant collectors for households relying on community forests for their fuel wood. Yet, our study introduced a new categorization of environmental degradation into different quality status. In the medium-deteriorated environment the wives' and schoolchildren's time spent on fuel wood fetching was affected differently. The effect, as expected, was positive and highly significant for schoolchildren but negative and highly significant for wives. This result demands an extra explanation which we already gave, namely, that the afforestation program accompanied with the effective by-laws forbid the villagers to harvest the newly flourishing-land cover in the neighbourhoods for domestic purposes. The villagers were allowed to collect a limited amount of dead wood from these nearby forests but the prohibitions against cutting live indigenous trees might be the main reason for the fuel wood shortage in these presently non-degraded villages, as the little dead wood might not be sufficient. That is why wives, being the principal fuel-wood collectors, spent relatively much time in the non-degraded environment while they spent less time in the medium-degraded environment.

With regard to joint effort, the hours spent by the wife on water and fuel wood fetching had significant positive effects on the time the husband spent on these activities. Also, if a husband fetched water at all, his time had a significant positive effect on the time the wife used on water fetching (see Table 3.9a, outcome equation). This means that the joint effort had a complementary element in the environmental product collection for household consumption. However, while the time school children spent on fetching did not have significant effects on the hours spent by their parents on these activities, yet, their participation was highly appreciable as it significantly reduced the probability that the male parent would spend hours on water and fuel wood-fetching (See Table 3.9a, selection equation). Furthermore, the participation of both a male parent and a schoolchild on out-door grazing significantly reduced the probability that a female parent would spend time on grazing probably because grazing is culturally a male burden (See Table 3b, selection equation). Although we commended that the hours wife and husband spent on collection were complementary, results further show that participation of the wife in fuel wood fetching significantly reduced the probability that the husband would spend time on fuel wood fetching because fuel wood fetching is culturally a female burden.

The parameter estimates for total household income in all household members' fuel wood and water fetching time outcome equations were negative. Though the parameters were not statistically significant (except for schoolboys on fuel wood collection), they nevertheless gave an indication that both fuel wood and water fetching are inferior goods for most subsistence households. Probably, had their income be higher, they would have opted for other sources of power such as kerosene, electricity or better energy saving stoves and better water systems like indoor tap water rather than roaming around fetching these goods in the open commons. Though we did not examine crop residue as part of the environmental products that the household members collected from the fields after harvest, however, our findings somehow confirmed the study by Amacher, Hyde and Kanel (1999) who found that relatively high income rural households in Nepal consumed fewer crop residues and therefore concluded that crop residue is an inferior good.

Table 3.9a. Heckman selection model : Two-step estimates for husbands. Dependent variable: Log collection/grazing time

	Water		**Fuel wood**		**Grazing**	
	Outcome equation	Selection equation	Outcome equation	Selection equation	Outcome equation	Selection equation
Medium-degraded, dummy[a]	0.038	-0.087	0.126	-1.559	0.482	0.264
	(0.133)	(0.294)	(0.157)	(0.396)***	(0.043)***	(0.218)
Severely-degraded, dummy[a]	0.209	0.706	-0.019	0.155	0.470	0.394
	(0.178)	(0.302)	(0.146)	(0.391)	(0.049)***	(0.233)
Farmer dummy[b]	0.137	1.296	-0.061	1.291	-0.109	0.635
	(0.282)	(0.725)	(0.220)	(0.689)	(0.082)	(0.388)
Government employee dummy[b]	-0.667	-0.154	-0.352	0.740	-0.235	-0.453
	(0.364)	(0.938)	(0.281)	(0.918)	(0.140)	(0.568)
Age	0.071	0.008	0.036	-0.093	0.029	0.141
	(0.056)	(0.129)	(0.047)	(0.152)	(0.019)	(0.100)
Age square	-1.071	-0.165	-0.584	1.299	-0.376	-2.006
	(0.785)	(1.844)	(0.664)	(2.173)	(0.272)	(1.424)
Log # males in the household	0.278	0.827	-0.282	1.606	0.118	1.916
	(0.228)	(0.564)	(0.219)	(0.632)	(0.143)	(0.46)***
Log # females in the household	-0.154	0.259	-0.119	0.891	-0.005	0.292
	(0.155)	(0.485)	(0.130)	(0.515)	(0.076)	(0.419)
Log # hours by wife per week	0.927	0.123	0.510	-1.435	0.161[a]	
	(0.104)***	(0.257)	(0.167)**	(0.449)**	(0.091)	
					0.325[b]	
					(0.135)	
Log # hours by schoolchild per week	0.045	-1.394	-0.018	-2.339	0.058[a]	
	(0.188)	(0.321)***	(0.104)	(0.549)***	(0.072)	
					0.036[b]	
					(0.085)	
Log hhold water/fuel in litres/kgs per week	0.330	-0.581	0.130	-2.339	0.016	
	(0.315)	(0.579)	(0.259)	(0.549)	(0.044)	
Log total hsehold income per week in Tsh.	-0.307	-0.452	-0.139	-0.636		0.223
	(0.121)	(0.250)	(0.114)	(0.294)		(0.209)
Pare ethnicity dummy[c]		-0.444		1.288		1.114
		(0.401)		(0.682)		(0.582)
Chagga ethnicity dummy[c]		-0.133		1.512		1.567
		(0.562)		(0.791)		(0.704)
Primary education, dummy[d]		-1.059		-1.456		-0.094
		(0.614)		(0.674)		(0.584)
Secondary education, dummy[d]		-0.539		-0.920		-0.046
		(0.676)		(0.715)		(0.630)
Constant	2.619	2.228	2.719	-1.408	2.120	4.398
	(2.812)	(6.753)	(2.334)	(7.931)	(0.902)	(4.942)
$Wald\ \ chi^2$	223.36		81.32		246.93	
$ta \Pr ob > chi^2$	0.000		0.000		0.000	
ρ	0.572		-0.430		0.181	
σ	0.255		0.185		0.181	
λ	0.146		-0.079		0.033	
	(0.188)		(0.120)		(0.110)	

Legend:

- **Water**: number of observations: 279; censored observations: 222; uncensored observations: 57 ≅ 20.4 percent
- **Fuel wood**: number of observations: 296; censored observations: 243; uncensored observations: 53 ≅ 17.9 percent
- **Grazing**: number of observations: 301; censored observations: 115; uncensored observations: 186 ≅ 61.8 percent

For **grazing**, because of the zero hours for wife and schoolchild, then the following technique was applied:

[a] (Dummy x log (hours))

[b] (1 – Dummy)

Where if not observed log (hours) = 0. Dummy = 1 if wife/child was grazing and 0 if else.

- [a] = reference category: Non-degraded. [b] = reference occupation is "other" [c]= reference tribe is "other".
- [d] = reference education level is "illiteracy"
- $P < .1$,* $P < .05$,** $P < .01$***
- standard errors of estimates between parentheses.

Table 3.9b. Heckman selection model : Two-step estimates for wives. Dependent variable: Log collection/grazing time

	Water		**Fuel wood**		**Grazing**	
	Outcome equation	Selection equation	Outcome equation	Selection equation	Outcome equation	Selection equation
Medium-degraded, dummy[A]	-0.115	-6.011	-0.170	-0.088	0.479	1.071
	(0.069)	(0.523)***	(0.042)***	(0.647)	(0.243)	(0.552)
Severely-degraded, dummy[A]	0.132		0.170	6.11	0.659	2.324
	(0.068)**		(0.048)***		(0.525)	(0.502)***
Farmer, dummy[B]		-2.938		-5.806		5.206
		(49.014)		(86.767)		(9.387)
Age	0.056	1.261	0.060	1.349	0.020	-0.025
	(0.037)	(1.313)	(0.023)*	(1.817)	(0.111)	(0.217)
Age square	-0.691	-15.562	-0.803	-19.721	-0.466	0.384
	(0.482)	(16.106)	(0.290)*	(25.132)	(1.421)	(2.844)
Log # males in the household					0.159	1.561
					(0.484)	(0.829)
Log # females in the household	0.009		0.016	-0.093	-0.530	0.438
	(0.018)		(0.011)	(0.183)	(0.262)	(0.654)
Log # hours by husband per week	0.013	-0.065	-0.000	-0.150	0.102	-2.247
	(0.005)**	(0.021)**	(0.005)	(0.120)	(0.436)	(0.793)**
Log # hours by schoolchild per week	-0.001	0.082	0.006	-0.003	-0.220	-0.991
	(0.004)	(0.072)	(0.004)	(0.168)	(0.268)	(0.362)**
Log hhold water/fuel in litres/kgs per week	-0.000	0.000	0.001			
	(0.000)	(0.001)	(0.000)			
Log total hsehold income per week in Tshs.	-0.036	0.187	-0.036	-1.291	-0.177	-0.209
	(0.056)	(0.674)	(0.035)	(0.996)	(0.200)	(0.343)
Pare ethnicity, dummy[C]						
Chagga ethnicity dummy[C]						0.478
						(0.542)
Constant	3.157		3.519	80.882	2.884	
	(1.534)**		(0.921)***		(4.586)	
Wald chi^2	202.06		124.97		74.20	
Pr *ob* > *chi*^{2}	0.000		0.000		0.000	
ρ	-0.655		0.215		0.755	
σ	0.374		0.230		0.327	
λ	-0.245		0.050		0.247	
	(0.402)		(0.319)		(0.341)	

Legend:

- **Water**: number of observations: 301; censored observations: 6; uncensored observations: 295 ≅ 98 percent
- **Fuel wood**: number of observations: 301; censored observations: 3; uncensored observations: 298 ≅ 99 percent
- **Grazing**: number of observations: 173; censored observations: 132; uncensored observations: 41 ≅ 23.7 percent
- [a] = reference category: Non-degraded. [b] = reference occupation is "other" [c]= reference tribe is "other".
- $P < .1$,* $P < .05$,** $P < .01$***
- standard errors of estimates between parentheses.

Table 3.9c. Heckman selection model : Two-step estimates for schoolchildren. Dependent variable: Log collection/grazing time

	Water		**Fuel wood**		**Grazing**	
	Outcome equation	Selection equation	Outcome equation	Selection equation	Outcome equation	Selection equation
Medium-degraded, dummy[a]	0.163 (0.061)**	-6.029 (3522.3)	0.244 (0.065)***	-6.862 (3015.6)	0.102 (0.086)	0.326 (0.226)
Severely-degraded, dummy[a]	0.280 (0.057)***	-5.552 (3522.3)	0.399 (0.067)***	-6.913 (3015.6)	0.304 (0.092)**	0.488 (0.227)
Schoolboy, dummy[b]	-0.045 (0.047)	-0.851 (0.423)**	-0.048 (0.043)	-0.975 (0.473)**	0.124 (0.054)**	-0.193 (0.191)
Log # hours by the father per week	-0.170[a] (0.082)	0.719[a] (2.097)	0.288[a] (0.242)	1.492[a] (8.835)	0.109 (0.119)	
	0.342[b] (0.100)**	-0.184[b] (1.910)	0.336[b] (0.183)	-0.794[b] (5.356)		
Log # hours by the mother per week	0.088 (0.051)	-0.498 (0.465)	0.165 (0.082)	0.352 (0.725)	0.197[a] (0.146)	
					0.447[b] (0.216)	
Class six education, dummy[d]		-5.672 (3522.3)		-5.413 (3015.6)		-0.384 (0.348)
Class five education, dummy[d]		-5.672 (3522.3)		-5.531 (3015.6)		-0.336 (0.371)
Class four education, dummy[d]		-5.661 (3522.3)		-5.048 (3015.6)		-0.187 (0.417)
Class three education, dummy[d]		-6.161 (3522.3)		-5.416 (3015.6)		-0.474 (0.474)
Class two education, dummy[d]		-5.601 (3522.3)		-5.831 (3015.6)		0.423 (0.561)
Class one education, dummy[d]		-6.223 (3522.3)		-7.095 (3015.6)		0.522 (0.885)
Age	0.074 (0.141)	-0.766 (1.827)	0.068 (0.132)	1.273 (1.964)	0.265 (0.246)	-2.166 (0.815)*
Age square	-0.546 (0.969)	6.037 (12.283)	-0.507 (0.906)	-7.703 (13.108)	-1.916 (1.699)	15.297 (5.720)*
Log hhold water/fuelwood per week	-0.312 (0.115)**	0.879 (0.900)	0.268 (0.087)**	-1.781 (0.851)		
Log hsehold income per week in Tshs.	-0.076 (0.046)	0.367 (0.466)	-0.089 (0.045)	0.514 (0.499)	-0.085 (0.060)	-0.037 (0.197)
# males in the household	-0.027 (0.019)	-1.980 (1.166)	-0.190 (0.112)	-1.937 (1.227)	-0.161 (0.186)	1.391 (0.502)*
# females in the household	0.051 (0.111)	1.740 (1.031)	0.041 (0.108)	2.643 (1.160)	0.106 (0.139)	0.761 (0.445)
Pare ethnicity, dummy[c]						1.462 (0.702)
Chagga ethnicity, dummy[c]						1.586 (0.798)
Sambaa ethnicity, dummy[c]						0.142 (0.890)
Constant	2.184 (1.732)	-0.067	0.526 (1.519)	28.660	3.516 (3.056)	-28.837 (10.070)**
$Wald\ \ chi^2$	78.45		87.70		79.29	
$\Pr ob > chi^2$	0.000		0.000		0.000	
ρ	-0.873		-0.522		0.10	
σ	0.305		0.286		0.295	
λ	-0.266 (0.210)		-0.149 (0.197)		0.028 (0.149)	

Legend:

- **Water**: number of observations: 301; censored observations: 16; uncensored observations: 285 ≅ 94.7 percent
- **Fuel wood**: number of observations: 301; censored observations: 16; uncensored observations: 285 ≅ 94.7 percent
- **Grazing**: number of observations: 290; censored observations: 116; uncensored observations: 174 ≅ 60 percent
- Because of the zero hours the following technique was applied to specific activity and member concerned:
  [a] (Dummy x log (hours)) [b] (1 – Dummy)
  Where if not observed log (hours) = 0. Dummy = 1 if wife/husband was collecting or grazing ; 0 if else.
- [a] = reference category: Non-degraded. [c]= reference tribe is "other". [d] = reference education level is "Class seven"
- [b] = reference gender is the schoolgirl
- $P < .1$,* $P < .05$,** $P < .01$***
- standard errors of estimates between parentheses.

Tables 3.9a, 3.9b, and 3.9c also show that individual characteristics like occupation e.g., being a farmer or government employee, and ethnicity e.g., being a Pare or Chagga, mostly appeared in the selection equations and were not significant. With the exception of the ethnicity of the household members for grazing, and with the exception of the ethnicity of the husband for fuel wood collection (the coefficients of which were positive), all other individual characteristics in collection and/or grazing activities consistently had non-significant negative coefficients. This means that these individual characteristics did not significantly influence the probability that household members would either increase or decrease their time spent on collection and/or grazing if they participated in these activities.

The study by Heltberg, Arndt, and Sekhar (2000) showed that both the number of males and the number of females had positive and significant impacts on fuel wood collection in rural India. Our study in South Pare shows a significant positive effect of the number of males within the household on grazing time only for husbands and schoolchildren while for fuel wood and water collection the effect was either positive or negative and not significant in all cases. Because the significant positive effect of the number of males on grazing appeared only in the selection equation, this technically implied that the participation of male household members in grazing significantly increased the probability (by the specified percentage points) that both husbands and schoolchildren would spend time in grazing. Though significant, it is however logically hard to derive sense from this implication.

In equation (9), we made some theoretical expectations with regard to the signs of the coefficients of the exogenous variables. We expected the coefficients of environmental quality, E, to be positive. We also expected a negative coefficient for household income and education levels of the household members. Furthermore, we expected positive coefficients for the amount of environmental products. Most of these coefficients show the expected signs. However, some of the sign expectations especially on the consumption quantity of environmental products were not met because of the non-separability of production and consumption decisions incorporated in the subsistence agricultural household model that we adopted for our analysis. That is, the household's production decisions affected its consumption, but its consumption decisions also affected household choices about production. Non-separability arises where there are incomplete markets and when households consume all of their own produce as in the rural South Pare highlands. We therefore agree with Cooke (2000) who asserts that it is not possible to sign the marginal effects of changes in many of the exogenous variables due to the non-separability of production and consumption decisions. In the non-separability situation, it falls to empirical estimation to determine the sign as well as the magnitude of the marginal effects (Cooke 2000). These marginal effects showed the responsiveness of households to changes in the relative scarcity of the environmental products.

3.7. Conclusion

This chapter investigated the effects of environmental degradation on intra-household labour time allocation to collecting scarce environmental products in the rural South Pare highlands. The results showed that environmental products collection and/or grazing activities were gender biased with men specializing in grazing while women specialized in water and fuel wood collection. Schoolchildren had no specialization but participated in all

these activities. However, their time allocation to each of these activities was limited. Of the factors that influenced labour time patterns, environmental quality played a significant role in all estimates.

Women and schoolchildren were significant fetchers of water and fuel wood while husbands were significant grazers. The long hours they spent on these collection and/or grazing activities might have an impact on agricultural productivity. This foreseen impact is analyzed in Chapter 4. Our assessment in this chapter has revealed that most of the household and individual characteristics did not have significant impact.

We admit the drawback in the methodology for collection of time allocation information for various collection and/or grazing activities. We employed a recall survey method, which might give room for either overestimation or underestimation of the time spent in a particular activity. Saksena *et al.*(1995), for instance, noted that women generally overestimated the time they spent on cooking. This does not imply that women did not value their time. What this reveals is that, in their day-to-day affairs, they did not find it necessary to quantify time (Saksena *et al.* 1995). Moreover, some of the household members did not have watches. Their time measurement based on time-aides like experience, sun-sight and regular time announcements on radio broadcasts after some news intervals. However, we tried to overcome the drawback in the methodology of time allocation information for various collection and/or grazing activities by comparing to hours reported in others studies[18] in the semi-arid areas of central Tanzania like Dodoma and Singida where environmental degradation was also noticeable.

[18] Some of these studies are Sieff (1997), Kabatange, Rukantabula, and Kitalyi (1984) and Johnsen (1999).

CHAPTER 4

ENVIRONMENTAL DEGRADATION, AGRICULTURAL PRODUCTION AND HOUSEHOLD CONSUMPTION OF HOME-PRODUCED MEALS

4.1. Introduction

This chapter provides empirical findings and analysis of resource scarcity, agricultural and household productivity in testing Hypothesis 2. We examine the influence of environmental degradation on both agricultural production and household consumption of the selected cereal crops in the study area.

The theoretical framework for this chapter is presented in Section 4.2. This is followed by the data descriptive analysis in Section 4.3. Section 4.4 discusses the estimation techniques we employ in regressions. The estimation results and discussions are offered in Section 4.5. The chapter concludes with Section 4.6.

4.2. Theoretical framework

The basis for the theoretical framework is a neo-classical model of agricultural household production as described in Singh, Squire, and Strauss (1986). In the case presented here, markets for some of the goods in the model do not exist and the goods must be produced by the household. The model begins with a representative household which is assumed to maximize its quasi-concave utility function. The utility function is written:

$$U = U(Y_m, Y, Z) \quad (1)$$

where Y_m is the household consumption of meals and Y is the consumption of a vector of market goods. Household utility is assumed to be conditioned on a vector of fixed household characteristics Z including ethnic background, educational level and household size which may affect preferences. The household purchases Y at market price p, however meals are assumed to be available from home production.

Households maximize their utility function subject to a set of production, budget, and time constraints. The production constraint for meals is given by

$$Y_m = Y_m(T_m^w, T_m^h, T_m^c, P_m, Y_{am}) \quad (2)$$

and is concave in all its arguments. T_m^w, T_m^h and T_m^c are the time the wife, the husband and the schoolchild[19] spent on meal production. P_m is a vector of environmental goods used as inputs to the meal production process, and Y_{am} is a vector of agricultural goods used in producing meals. For example, P_m contains water and fuel wood, and Y_{am}

[19] Note that only one child from each household was interviewed.

contains meal ingredients such as rice, millet, beans and maize. These four crops are the cereals selected in this work because they are the main meal constituents.

Agricultural inputs may be bought in the market place at p_a or may be produced by the household. Environmental goods are assumed to be available only from home production. The household's agricultural production function is given by:

$$Y_a = Y_a[T_a^w, T_a^h, T_a^c, , P_a, P_{al}, K] \tag{3}$$

which is assumed to be concave and increasing in all its arguments. Y_a is the production of crops which may be either sold or consumed by the household. Agricultural labour used on a household's farm comes from the wife's labour, T_a^w, the husband's labour, T_a^h, and the schoolchild's labour, T_a^c. Production also depends on the amount of land a household has available for use, P_{al}, livestock holding, K, and agricultural market-priced inputs P_a. Landholdings and livestock are assumed to be exogenous in this model. Livestock, K, contributes to agricultural production primarily by providing manure and oxen for ploughing. P_a contains goods such as grass which is fed to livestock, and thus contribute to fertilizer production. The production functions for P_m and P_a are given by:

$$P_m = P_m(T_{mr}^w, T_{mr}^h, T_{mr}^c, E, Z) \tag{4}$$

$$P_a = P_a(T_{ar}^w, T_{ar}^h, T_{ar}^c, E, Z) \tag{5}$$

These production functions differ only in the time variables for environmental good collection and/or grazing, subscripted "*mr*" and "*ar*" for time devoted to meal-related environmental goods and agriculturally-related environmental goods, respectively. In this formulation; the wife's, the husband's and the schoolchild's time is spent on environmental good collection and/or grazing although they are not considered perfect substitutes and may differ in degree depending on gender and age. Both production functions are assumed to be linear functions of the time inputs implying constant marginal products for husband and wife labour for a given household. The vector of the household characteristics, Z, and the state of the environment the household faces, E, will also influence the production of both types of environmental goods. For example, households comprised of aged parents may have lower marginal products, and on the other hand, households in locations where open forest resources are severely-degraded may also have lower marginal products. Since Z and E will differ across households, marginal products of labour will differ across households as well.

The household time constraints are given in equations (6), (7) and (8). The husband, the wife and the schoolchild are all assumed to have a fixed endowment of available work time given by T^w, T^h and T^c, respectively. We assume that both the wife and the husband use their time for preparing meals, collecting environmental goods used in meal and agricultural production, farm agricultural labour, and wage labour if formally employed (subscripted *m, mr, ar, a, and j,* respectively). The schoolchild uses his/her time for preparing meals, collecting environmental goods used in meal and agricultural production, farm agricultural labour, and schooling. Schooling is subscripted "*s"*.

$$T^w = T_m^w + T_{me}^w + T_{ag}^w + T_a^w + T_j^w \tag{6}$$

$$T^h = T_m^h + T_{me}^h + T_{ag}^h + T_a^h + T_j^h \tag{7}$$

$$T^c = T_m^c + T_{mr}^c + T_{ar}^c + T_a^c + T_s^c \tag{8}$$

Household purchases of Y at market price p are constrained by the amount of household income, I, a household receives, and its net earnings from selling agricultural products and labour. It is assumed that environmental products are neither bought nor sold and are consequently available only from household production. A household may buy and sell agricultural products at the price p_a. For the purpose of this model, agricultural products and other market goods Y are assumed to be available in perfectly functioning competitive markets. The household may also buy and/or sell the husband's and the wife's labour in competitive markets at wage rates W^h and W^w, respectively. This assumption implies that labour market opportunities exist for both husbands and wives. However, statistics tell us that only 7 percent of the husbands from the sample households and 2.6 percent of the wives from the same sample have formal employment either in the government sector, or in the private sector, or are self-employed in petty business. Schoolchildren are, by law, prohibited to have formal employment e.g. in government and private offices while still schooling. The household's total budget constraint then is given by:

$$p_a\left(Y_a - Y_{am}\right) + W^h T_j^h + W^w T_j^w + I_e = pY \tag{9}$$

Substituting the production functions and the time constraints into the budget constraint or into the utility function, the Lagrangian function for the household's maximization problem may be written:

$$\begin{aligned} Max\ \ell = U\{Y_m\left[T_m^w, T_m^h, T_m^c, P_a(T_{mr}^w, T_{mr}^h, T_{mr}^c, E, Z), Y_{am}\right]; Y; Z\} + \lambda\{p_a\left[Y_a\left(T_a^w, T_a^h, T_a^c, P_{al}, K\right) - Y_{am}\right] \\ + W^h(T^h - T_{mr}^h - T_{ar}^h - T_a^h) + W^w(T^w - T_m^w - T_{mr}^w - T_{ar}^w - T_a^w) + I_e - pY\} \end{aligned} \tag{10}$$

with the household choosing Y, Y_{am} and all time inputs. Note that the formal work time for the schoolchild is excluded from the Lagrangian function because it is not implicated in the household's total budget constraint in equation (9) as the schoolchild is not legally permitted to have formal employment that would bring income to the household.

Assuming an interior solution, the first-order conditions may be derived and solved simultaneously for a set of reduced-form demand equations. One may also obtain derived demands for P_a and P_m. All demands will be functions of the exogenous variables $(W^h, W^w, p_a, p, K, P_{al}, E, Z, I_e)$ and the shadow prices. The shadow prices themselves are functions of the exogenous variables and the quantity of the environmental product a

household chooses to use (that quantity being determined here by the amount of the time a household chooses to spend collecting the good). The first-order conditions may be arranged to give:

$$\left(\frac{W^h}{P_{TM_{mr}}}\right)/p_a = \left(\frac{W^w}{P_{TW_{mr}}}\right)/p_a = \left[U_{Y_m}(Y_m)_{P_m}\right]/\left[U_{Y_m}(Y_m)_{Y_{am}}\right] \qquad (11)$$

from which we may define the shadow price for meal-related environmental goods

$$\Pi_{P_m} = \left(\frac{W^h}{P_{TM_{mr}}}\right) = \left(\frac{W^w}{P_{TW_{mr}}}\right) \qquad (12)$$

The terms $P_{TM_{mr}}$ and $P_{TW_{mr}}$ are the marginal products of the time spent in meal-related environmental good collection by husbands and wives, respectively. The shadow price Π_{P_m} is defined as the husband's or wife's wage rate divided by the marginal product of one's labour in the meal-related environmental good production. Equation (11) gives the condition that a household will consume P_m and Y_{am} until the ratio of their "prices" equals the ratio of the marginal utilities the household receives from an additional unit of them. Π_{P_m} is determined endogenously by the household choices. Specifically, it will depend on household preferences for meals. Since these preferences will vary from household to household, so will this shadow price (see Singh, Squire, and Strauss; 1986).

The first-order conditions also yield the similarly defined shadow price of environmental goods used in agriculture:

$$\Pi_{P_a} = \left(\frac{W^h}{P_{TM_{ar}}}\right) = \left(\frac{W^w}{P_{TW_{ar}}}\right) = Y_{a_{P_a}} p_a \qquad (13)$$

Here, $P_{TM_{ar}}$ and $P_{TW_{ar}}$ are the marginal products of husband's and wife's labour in agricultural-type environmental good production and $Y_{a_{P_a}}$ is the marginal product of P_a in agricultural production. This shadow price Π_{P_a} will depend on a household's agricultural technology as well as household preferences, and a household will equate this shadow price to the value of the marginal product of P_a.

The shadow prices are assumed to reflect the relative economic cost of environmental products to a household. Controlling for endogenous productivity factors, this cost is largely determined by the environmental conditions a household faces. A household living in relatively severely-degraded environmental conditions will have to spend more time to collect a unit of the product than will a household living in non-degraded environmental conditions. Hence, households in severely-degraded environmental conditions will tend to have higher shadow prices. The shadow prices might also be influenced by a household's wage rates. However, since very few husbands and wives have formal employment, we think that the wage rates' influence in this case is minimal.

4.3. Data descriptive analysis

All sample households collect and use environmental products, and all households are agricultural. Tables 4.1a,b,c show the average acres of land per household for survey food crops of maize, millet, paddy and beans in each of the three environmental conditions.

Table 4.1a,b,c. Average land use (acre) and yields (kilograms) for each surveyed food crop by village and environmental condition.

(a)

	Non-degraded (the upland plateau zone)							
	Gwanga		Gonzanja		Kirangare			
Crop	Land use (acre)	Yield (kgs)	Land use (acre)	Yield (kgs)	Land use (acre)	Yield (kgs)	**Total Land use (acres)**	**Total yield (kgs)**
Maize	2.0	233.0	2.1	267.0	2.4	408.0	**6.5**	**908.0**
Beans	1.5	112.0	1.7	157.0	1.7	75.0	**4.9**	**344.0**
Millet	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**
Paddy	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**
Total	**3.5**	**345.0**	**3.8**	**424.0**	**4.1**	**483.0**	**11.4**	**1252.0**

(b)

	Medium-degraded (the middle plateau zone)							
	Mgwasi		Vumari		Kizungo			
Crop	Land use (acre)	Yield (kgs)	Land use (acre)	Yield (kgs)	Land use (acre)	Yield (kgs)	**Total Land use (acres)**	**Total yield (kgs)**
Maize	2.7	597.0	3.4	1129.0	3.6	1616.0	**9.7**	**3342.0**
Beans	2.3	298.0	0.5	69.0	0.9	262.0	**3.7**	**629.0**
Millet	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**
Paddy	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**
Total	**5**	**895.0**	**3.9**	**1198.0**	**4.5**	**1878.0**	**13.4**	**3971.0**

(c)

	Severely-degraded (the lowland zone)									
	Ishinde		Njoro		Mgandu		Mvure-kongei			
Crop	Land use (acre)	Yield (kgs)	Land use (acre)	Yield (kgs)	Land use (acre)	Yield (kgs)	Land use (acre)	Yield (kgs)	**Total Land use (acres)**	**Total Yield (kgs)**
Maize	3.1	1090.0	2.1	713.0	1.3	1260.0	0.9	590.0	**7.4**	**3653.0**
Beans	1.2	194.0	1.0	141.0	1.2	430.0	0.9	108.0	**4.3**	**873.0**
Millet	0.1	1.8	0.4	2.0	0.0	0.0	0.0	0.0	**0.5**	**3.8**
Paddy	0.0	0.0	0.0	0.0	0.4	640.0	0.9	927.0	**1.3**	**1567.0**
Total	**4.4**	**1285.8**	**3.5**	**856.0**	**2.9**	**2330.0**	**2.7**	**1625.0**	**13.5**	**6096.8**

The common staple food in the area is *ugali*, a *stiff porridge made of maize flour*, which is usually eaten together with cooked beans. The other foodstuff most preferred by the local people is *kande, a mixture of fine small pieces of maize cobs boiled together with some beans.* Sample households therefore mainly grow maize and beans on household farms, and most of them heavily rely on their own farm's production for their food consumption.

To produce food, survey households owned at least some land with a sample average of slightly over 2 acres (0.8 ha) and less than 4 acres (1.6 ha) per household in maize production, and slightly over $1\frac{1}{2}$ acres (0.6 ha) in beans production. Very few households cultivated millet and paddy on their farms, and if they did, they mainly grew these crops in the lowland on farms of less than 0.9 acres on average. No households attempted to cultivate paddy in either upland or middle-plateau zones for the 2005/6 agricultural season. Maghimbi (2007) says that paddy has always been grown in the flood plains and the river valleys of the lowland zones in South Pare. Farmers know better their environment and they are therefore aware that it is not ideal to grow rice on these zones where there are no valleys and possibly floods. Basically maize, millet, paddy and beans are grown in the lowlands. Maize is the dominant food crop in the South Pare highlands. The bulk of maize is grown in the lowlands surrounding the Pare mountains. During the short rainy season commonly known as *vuli*, maize is also grown at high-altitudes, 3,000 to 6,000 feet above sea level (Maghimbi, 2007). Tables 4.1a,b,c show that for the 2005/6 agricultural season, production yields of maize, millet, paddy and beans were higher in the lowlands than in the upland and the middle plateau zones. The total yield of maize from the survey households in the severely-degraded area was 3,653 kilograms, in the medium-degraded area it was 3,342 kilograms and in the non-degraded area the yield was 908 kilograms only. The production of beans with total yields in brackets were: in the severely-degraded area (873 kilograms), the medium-degraded area (629 kilograms) and the non-degraded area (344 kilograms). Millet and paddy were grown by the survey households neither in the non-degraded nor in the medium-degraded areas for the 2005/6 agricultural season. In the severely-degraded area, however, millet and paddy were grown and yielded a total of 3.8 kilograms of millet and 1567 kilograms of paddy, respectively. In comparison with other survey crops, the 2005/6 agricultural year was worse for millet production in South Pare.

We also note from Tables 4.1a,b,c that the high yields for the 2005/6 agricultural season were recorded in the villages located in either medium or severely-degraded environments. The highest total output among the survey villages was recorded in Mgandu village (2,330 kilograms) followed by Kizungo (1,878 kilograms), Mvure-kongei (1,625 kilograms), Ishinde (1,265.5 kilograms), Vumari (1,198), Mgwasi (895 kilograms) and Njoro (856 kilograms). All these villages are either in Medium or severely-degraded areas, in the middle-plateau zone and lowland, respectively. There is thus a topographical logic behind the farm performance of the survey crops. The survey crops (maize, beans, millet and paddy) are cereals, which biologically yield better in either lowland or medium plateau land than at high altitudes, ceteris paribus (Maghimbi, 2007).

Farm mechanization in the area is simple, traditional and undeveloped. About 77 percent of South Pare's cropped land of the survey households was cultivated by hand hoe, 4 percent by ox-plough and 19 percent by tractor, especially on the lowland. Tables 4.2a,b,c

show the response to the research questions concerning whether the villages used tractors, ox-ploughs, and/or fertilizer (organic, inorganic or both).

Table 4.2a, b, c. Use of agricultural implements by environmental degradation and village

(a)

		Non-degraded (the upland plateau zone)		
		Gwanga	Gonzanja	Kirangare
Tractor use	(yes = 1, no = 0)	0	0	0
Fertilizer use	(yes = 1, no = 0)	1	1	1
Fertilizer type	(organic=1;inorganic=2;both=3; not applicable=4)	3	1	1
Ox-plough	(yes=1, no = 0)	0	0	1

(b)

		Medium-degraded (the middle plateau zone)		
		Mgwasi	Vumari	Kizungo
Tractor use	(yes = 1, no = 0)	0	1	1
Fertilizer use	(yes = 1, no = 0)	1	1	1
Fertilizer type	(organic=1;inorganic=2;both=3; not applicable=4)	3	1	1
Ox-plough	(yes=1, no = 0)	0	0	0

(c)

		Severely-degraded (the lowland zone)			
		Ishinde	Njoro	Mgandu	Mvure-kongei
Tractor use	(yes = 1, no = 0)	1	1	1	1
Fertilizer use	(yes = 1, no = 0)	1	1	1	1
Fertilizer type	(organic=1;inorganic=2;both=3; not applicable=4)	1	1	3	3
Ox-plough	(yes=1, no = 0)	0	0	1	0

Tractors were not at all put into use in the non-degraded areas and in one village (Mgwasi) in the medium-degraded area. These are upland and middle plateau zones. The rolling topography in the highlands makes mechanical traction difficult, forcing farmers to prepare land by hand (Nkonya *et alia* (1998). All villages in the lowland and two in the medium-degraded area (Vumari and Kizungo) hired tractors from relatively well-to-do individuals for land preparation. From the survey households, two villages, one from the non-degraded area (Kirangare) and the other from the severely-degraded area (Mgandu) made use of ox-ploughs for land preparation. All villages in which survey households resided applied fertilizers though at different degrees and types. About 51 percent of the sample households used fertilizers. Out of the fertilizer users, 41 percent applied organic, 23 percent applied inorganic and the remaining 36 percent preferred to apply both types of fertilizer. Organic fertilizer was used amongst the farmers almost in all villages. It was the most preferred type of fertilizer probably because it was freely collected within the vicinity of the households at the cattle stables without strictly involving a direct monetary price. Inorganic fertilizer was the least used of the two. When made available, it was used by a

few farmers in Gwanga, Mgwasi, Mgandu and Mvure-kongei villages where both types of fertilizers were applied. However, the application of fertilizer was very limited in the area. Only 21 percent of the total survey households used organic, 12 percent used inorganic and only 17 percent applied both types of fertilizer for the agricultural season of 2005/6.

Table 4.3 shows the use percentages of each agricultural implement by village and environmental condition. Of the ten survey villages, the tractors were reported to be mostly used in Mgandu village, the lowland zone, where about 83 percent of the survey households reported "yes" to the use of tractors in farming. In Mgandu village, the use of tractors, ox plough (37 percent) and fertilizer (100 percent) might have contributed to taking the lead in total staples production for the 2005/6 agricultural year amongst the survey households (see Table 4.1; an average sum of 2,330 kilograms for all survey crops).

Table 4.3. Use of agricultural implement by environmental degradation and village

	Non-degraded (the upland plateau zone)			Medium-degraded (the middle plateau zone)			Severely-degraded (the lowland zone)			
	Gwanga	Gonzanja	Kirangare	Mgwasi	Vumari	Kizungo	Ishinde	Njoro	Mgandu	Mvure-kongei
Tractor use (%)	0	0	0	0	10	33	20	40	83	7
Fertilizer use (%)	93	87	87	13	3	13	3	20	100	97
Ox-plough (%)	0	0	3	0	0	0	0	0	37	0

Other villages that used tractors for the 2005/6 agricultural year with use percentages in brackets were Njoro (40), Ishinde (20), and Mvure-kongei (7) in the severely-degraded environment; Vumari (10), and Kizungo (33) in the medium-degraded environment. Though land topography in both the medium and the severely-degraded areas favours motorized mechanization, the use percentage of tractors (with the exception of Mgandu village) was below 50 percent. Access to tractors was mainly limited by the low income which made the peasants unable to either purchase or hire the equipment. We observed during the fieldwork that tractors were hired at a cost of Tanzanian Shillings (Tshs.) 35,000 per acre (0.4 hectare) which, given their income, the peasants could hardly afford to pay while output from the land was very uncertain. In the 2005/6 agricultural season, Tanzanian shillings 35,000 were equivalent to 29.20 US dollars at the exchange rate of Tshs. 1,200 per one US Dollar. The mean per capita household monthly income in South Pare in 2005 was Tshs. 12,917, which then was equivalent to 10.76 USD. The reported mean per capita household monthly income in the area was less than the Tanzania Mainland rural average of 14,128 Tshs which, was equivalent to 11.77 USD in 2005 (Same District Council, 2006; Ikeno, 2007; Gordon and Enfors, 2008).

The use percentage of fertilizer among the survey households for the 2005/6 agricultural season, regardless of the fertilizer type, was encouraging. Over 80 percent of the survey households in each of the 5 villages applied fertilizer in farming. These villages, with use percentage in brackets are Mgandu (100), and Mvure-kongei (97) in the severely-degraded area; Gwanga (93), Gonzanja (87), and Kirangare (87) in the non-degraded area. At most 20 percent of the households in the villages located in the medium-degraded environment and one village (Ishinde) in the severely-degraded area used fertilizer in agriculture. Since organic fertilizer was the most preferred type because of its free

collection within the vicinity of the households, it would be impractical to collect and use much of it in the medium-degraded area because the open-accessed rangeland is normally located in the lowland (severely-degraded area) where the animals are grazed almost the whole day. The little manure collected at the cattle stables might not raise the use percentage to high levels. Fertilizer use in the non-degraded area was high because, as it was said earlier, given the rolling nature of the land topography and active by-laws to prevent deforestation, most households were forced to practice in-door grazing thus making it easier to have all animal manure settled in one place.

Despite the South Pare households keeping some cattle herd, employment of animal traction amongst survey households was minimal and only reported in Kirangare and Mgandu villages. Only 3 percent of the survey households in Kirangare village reported to use ox-plough in farming. In Mgandu village, about 37 percent of the survey households applied animal traction in agriculture. Reasons behind the minimal utilization of animal traction were not established. The lack of technical know-how of effective use of animals for land ploughing and other agricultural production purposes could contribute to the problem.

Collecting environmental products, engaging in farm agricultural activities, and preparing food for consumption require a very large proportion of a household's available work time. Table 3.2 presented the average time taken by the household members per week in various activities including agriculture and household works. However, the interest of Chapter 3 was on labour time allocation for collection and/or grazing activities, and therefore labour time allocation on agriculture and household activities was not discussed and kept pending for this chapter.

4.3.1. Agricultural labour time

The average time allocation data for husbands, wives, schoolboys and schoolgirls presented in Table 3.2 (Chapter 3) shows that agricultural work of husbands and wives was the most intensive in the middle-plateau zone where the environment is medium-degraded. However, for both schoolboys and schoolgirls, agricultural work was the most intensive in the lowland where the environment is severely-degraded. Tables 4.4a,b,c and Figure 4.1 show the mean hours family members spent daily on agricultural work by environmental condition and village.

Table 4.4a, b, c: The mean hours that household members spent daily on agricultural work by environmental condition and village.

	Non-degraded (the upland plateau zone)			
	Gwanga	Gonzanja	Kirangare	**Average[aa]**
Wife	6.27	6.03	6.87	**6.39**
Husband	6.50	5.90	6.00	**6.13**
Schoolchild	2.37	2.57	4.72	**3.22**
Total	**15.64**	**14.60**	**17.59**	**15.74**

(b)

	Medium-degraded (the middle plateau zone)			
	Mgwasi	Vumari	Kizungo	**Average[aa]**
Wife	5.90	6.80	6.94	**6.55**
Husband	6.00	7.00	7.90	**6.96**
Schoolchild	4.44	0.71	3.19	**2.79**
Total	**16.34**	**14.51**	**18.13**	**16.30**

(c)

	Severely-degraded (the lowland zone)				
	Ishinde	Njoro	Mgandu	Mvure-kongei	**Average[aa]**
Wife	4.47	6.31	6.17	7.20	**6.04**
Husband	6.00	6.00	5.90	7.20	**6.28**
Schoolchild	1.52	3.52	3.97	6.93	**3.99**
Total	**11.99**	**15.83**	**16.14**	**21.13**	**16.31**

Note:

- [aa] **Average hours** were computed by taking the summation of the labour hours a family member spent on agriculture in all villages of the respective environmental degradation condition divided by the total number of a family member in question, e.g. a wife, a husband or a schoolchild residing and working in that particular environment.

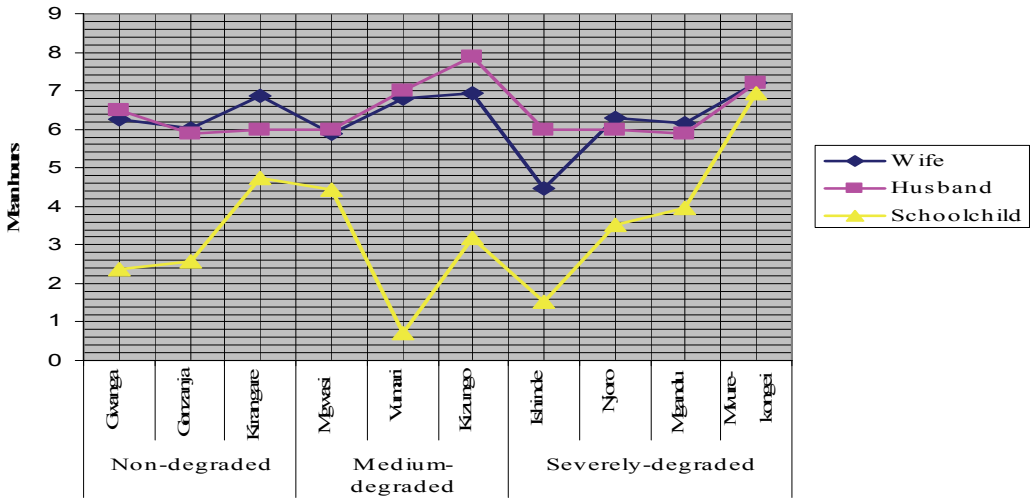


Figure 4.1. Mean hours spent on agriculture by village and environmental condition.

The highest average time that husbands reported to work daily on the agricultural farm was 7.90 hours in Kizungo village where the environment is medium-degraded. For both wives and schoolchildren, the highest average time recorded was 7.20 hours and 6.93 hours respectively in Mvure-kongei village in which the environment is severely-degraded. The lowest average time that husbands worked daily on agriculture was 6.90 hours in Gonzanja village (non-degraded area), and Mgandu village (severely-degraded area). For wives, the lowest average time they worked daily on the agricultural farm was 4.47 hours in Ishinde village. For the schoolchildren the lowest average reported time spent on agriculture was 0.71 hours in Vumari village (medium-degraded area). Basing on labour hours, Figure 4.1 shows that, despite minor variation, husbands and wives participated fairly equally in agricultural work. Furthermore, Figure 4.1 shows that there was not much difference across areas for the time spent on agriculture amongst husbands and wives. We observed during the 2006/7 fieldwork that the adult human power, using hand hoes, was the simplest and most basic level of agricultural mechanization. But humans had a low capacity and efficiency as a source of power and their labour input to cultivate, say an acre of land, would almost match their capacity despite the differences in environmental degradation.

4.3.1.1. Seasonal time reallocation

The agricultural year in South Pare, as it is in most parts of Tanzania, generally starts from the month of October and ends in September of the following year. The agricultural year covers two periods, namely, the dry period commonly called *kiangazi* and the rainy period. The rainy period is further divided into two seasons: *Vuli* and *masika* seasons. The *vuli* season is a short rain season that normally runs from October to January. The *masika* season is a long rainy season, which normally runs from March to May. However, due to deforestation, the long rainy season is affected and long-drought periods are experienced instead (Mvungi 1995; Omari 1995).

Time used for agriculture presented here is the average daily time for each household member based on the recall method regardless of the season. We obtained some rough ideas about the seasonal pattern of time allocation from which agriculture suffered because time was reallocated to other routine collection and/or grazing activities by asking the following question for each household member interviewed and for each routine activity under survey: *"In which season last year did you have to reallocate your time for other activities most often so that you could go on grazing… fetch water …collect fuel wood?*" The two words in the question "*other activities*" refer to farm and/or household works for husbands and wives; and the same words refer to school attendance, school-related activities like take-home assignments and private studies for schoolchildren. Schoolchildren are not spared from farm and/or domestic activities whenever their physical labour is demanded whether at free will or by force of their parents. Farm work refers to such activities in crop production as site clearing, land preparation, sowing and planting, weeding, harvesting, transportation, threshing, processing and storage activities. The answer to the question for parents is reported in Table 4.5. The schoolchild's response to the above question is reported in Chapter 5 when dealing with the effects of environmental degradation on the primary schooling of the children. However, there are no basic differences in the responses of parents and children.

Table 4.5 shows that a large percentage of female respondents in each environmental condition cited the dry season as a season in which they reallocated their

time most often so that they could fetch water and collect fuel wood from open commons. The question resulted in "non-applicable" answers from many husbands as water fetching and fuel wood collection activities are traditionally considered female work. On the other hand, the majority of husbands in all environmental conditions agreed that the dry season was the period where they reallocated their time most often from farm works to take animals for out-grazing. Most women, about 74 percent in each environmental condition, responded to the question as "not applicable" because grazing is traditionally male work.

However, it is clear from Table 4.5 that seasonality may have limited effects on our analysis of South Pare because the longest period in the area is the dry season in which all these routine activities have to take place. The rainy season is currently short-lived and may not, on average, disturb the time allocation patterns much. When it rains, it does not rain for the whole season but for very few hours on the so-called "lucky days". Eriksen , Brown and Kelly (2005) observed that drought associated with long sunny days, harvest failures and incidences of widespread household food insecurity or exhausted food stocks have been regular events in Pare during the twentieth century, and have been identified as being due to a convergence of social, political as well as natural factors (see also Chapter 2, this thesis).

Table 4.5. The season household members reallocate their time most often from farm work to collection and/or grazing activities – responses in percentages (%).

	Severely-degraded			Medium-degraded			Non-degraded		
	Dry season	Rainy season	Not applicable	Dry season	Rainy season	Not applicable	Dry season	Rainy season	Not applicable
Water fetching									
Husband	23.3	4.2	72.5	14.3	0.0	85.7	10.0	0.0	90.0
Wife	79.2	5.0	15.8	61.5	2.2	36.3	76.7	3.3	20.0
Child	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Fuel wood collection									
Husband	18.3	7.5	74.2	3.3	0.0	96.7	16.7	2.2	81.1
Wife	49.2	49.2	1.7	57.1	16.5	26.4	88.9	7.8	3.3
Child	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Grazing									
Husband	55.8	10.0	34.2	49.5	16.5	33.0	51.1	1.1	47.8
Wife	21.7	4.2	74.2	4.4	4.4	91.2	11.1	0.0	88.9
Child	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Legend: n/a – not applicable

4.3.2. Household labour time

Tables 4.6a,b,c and Figure 4.2 show the mean hours the family members spent daily on housework by environmental condition and village. By housework we refer to such activities as cleaning, cooking and childcare. Cleaning involves sweeping, making-up beds and doing the laundry; cooking involves preparing meals in the kitchen, washing dishes and serving at table. Childcare is associated with the attention given to babies at home.

Table 4.6a ,b ,c. The mean hours that household members spent daily on housework by environmental condition and village

(a)

	Non-degraded (the upland plateau zone)			
	Gwanga	Gonzanja	Kirangare	**Average[bb]**
Wife	3.27	3.13	8.27	**4.89**
Husband	1.28	0.00	1.53	**0.94**
Schoolchild	2.37	1.82	1.09	**1.76**
Total	**6.92**	**4.95**	**10.89**	**7.59**

(b)

	Medium-degraded (the middle plateau zone)			
	Mgwasi	Vumari	Kizungo	**Average[bb]**
Wife	4.77	3.51	6.38	**6.82**
Husband	0.74	0.75	4.42	**2.00**
Schoolchild	2.38	1.14	1.84	**1.79**
Total	**7.89**	**5.40**	**12.64**	**10.61**

(c)

	Severely-degraded (the lowland zone)				
	Ishinde	Njoro	Mgandu	Mvure-kongei	**Average[bb]**
Wife	3.14	9.77	8.33	8.93	**7.54**
Husband	1.06	0.53	3.23	2.37	**1.80**
Schoolchild	1.39	2.44	2.67	4.0	**2.62**
Total	**5.59**	**12.74**	**14.23**	**15.3**	**11.96**

Note:

- [bb] **Average hours** were computed by taking the summation of the labour hours a family member spent on housework in all villages of the respective environmental degradation condition divided by the total number of a family member in question, e.g. a wife, a husband or a schoolchild residing and working in that particular environment.

Tables 4.6a,b,c and Figure 4.2 show that housework in South Pare was predominantly work of the housewife. She was taking the lead in all environmental degradation conditions and in all survey villages. Schoolchildren, regardless of their gender, fell second while husbands (with exception of Kizungo, Mgandu and Kirangare villages) were tailing by far last. Housework took at least 3 hours of a wife's time in a non-degraded environment to an average of nearly 10 hours in a severely-degraded environmental condition. On the other hand, housework took 0 hours of husband's time in a non-degraded environment to a maximum average of 4.42 hours in a medium-degraded environment and 3.23 hours in a severely-degraded environment.

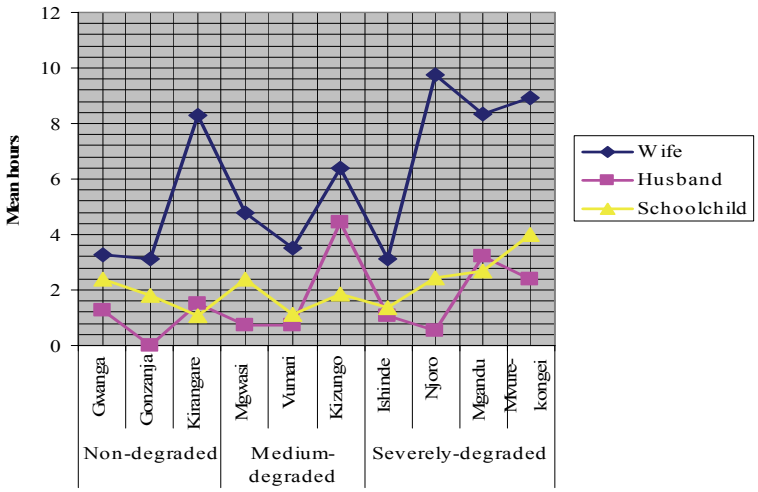


Figure 4.2. Mean hours spent daily on housework by village and environmental degradation.

It is amazing to note that while husbands and wives participated fairly equally in crop production (see Figure 4.1), women alone carried major responsibility for domestic work (Figure 4.2). Wives' total reported housework labour time was about 374 percent of husbands' total reported housework labour time. This gives an indication that adult males had more leisure hours available for ease and relaxation free from responsibilities than adult females. The centrality of adult females' domestic tasks in South Pare was dramatised by a personal experience during the fieldwork in 2006/7. It was common to observe adult males refreshing themselves with local brews in the local pubs at evening hours, when at the same time, adult females were at home preparing hot meals for their respective families.

Of interest in the household labour time is the cooking time that enters into the production constraint for meals (refer equation (2)). Cooking, like other household chores, is a routine task the time burden of which falls heavily on the wife because she tends to be responsible for the household tasks. On average, the South Pare households cook three meals per day. Where food shortages occur or meal-related supplies such as fuel wood and water are low, this frequency may drop to two. Our fieldwork data shows that 17.6 percent of the survey households cooked two meals per day and the remaining 82.4 percent had three hot meals per day. The local breakfast typically consists of maize-flour porridge or rice cakes, or leftovers from the previous night's dinner. For lunch and dinner, their diet commonly includes *ugali, kande*, or rice, which are common staple foods that are mostly combined with beans, or vegetable stew. The amount of food cooked and made available for consumption is expressed in calories per person, per day[20]. The average per capita daily calorie supply of the survey household members in 2005/6 agricultural season was 1,860 calories in the non-degraded environment, 2,224 calories in the medium-degraded environment, and 2,227 calories in the severely-degraded environment. Generally, the daily calorie supply per capita in South Pare, regardless of the environmental degradation situation, was far below the developing countries' estimates of 2,675 in 2004, and almost

[20] The average per capita daily calorie supply is derived by dividing the total calories obtained from the daily consumption of various meals in the household by the household size. The formula for computing the caloric intake is given in the estimation techniques (Section 4.4). The calorie supplies are reported in kilocalories.

equal to the Food and Agricultural Organization's (FAO) recommended minimum caloric intake levels of approximately 2,100 calories per day (USDA, 2007). In this regard, and with respect to the survey crops, a person living in the non-degraded environment was considered food insecure or hungry. This could be an underestimate because only 4 food categories were counted.

Food is commonly boiled or roasted. In some cases, food preparation may involve several hours of cooking time, with an inevitably higher input of cooking energy. The common cooking device is the traditional three-stone fire settled either inside or outside the house. Sometimes a small kitchen hut, in a simple structure, is built adjacent to the main house. The survey households do not have electricity as a source of energy, and kerosene (paraffin) is generally limited to lighting at night. The constraint against using kerosene for cooking is its cost, and the necessary expenditure for the special stove equipment. Cooking on the traditional three-stone fire is usually associated with poor combustion resulting in excessive smoke emissions especially when the fuel wood is wet or not dry enough.

Tables 4.7a,b,c and Figure 4.3 show the mean hours the family members spent daily on cooking by environmental condition and village.

Table 4.7a, b, c. The mean hours that household members spend daily on cooking by environmental condition and village

(a)

	Non-degraded (the upland plateau zone)			
	Gwanga	Gonzanja	Kirangare	**Average[cc]**
Wife	1.09	1.04	2.76	**1.63**
Husband	0.55	0.00	1.00	**0.71**
Schoolchild	0.79	0.63	0.38	**0.60**
Total	**2.43**	**1.67**	**4.14**	**2.94**

(b)

	Medium-degraded (the middle plateau zone)			
	Mgwasi	Vumari	Kizungo	**Average[cc]**
Wife	1.59	1.21	4.00	**2.30**
Husband	0.00	0.93	2.48	**1.70**
Schoolchild	0.83	0.49	0.66	**0.67**
Total	**2.42**	**2.63**	**7.14**	**4.67**

(c)

	Severely-degraded (the lowland zone)				
	Ishinde	Njoro	Mgandu	Mvure-kongei	**Average[cc]**
Wife	1.05	3.26	2.78	2.98	**2.51**
Husband	0.37	0.00	0.00	0.33	**0.37**
Schoolchild	0.46	0.81	1.03	1.33	**0.90**
Total	**1.88**	**4.07**	**3.81**	**4.64**	**3.78**

Note:

- [cc] **Average hours** were computed by taking the summation of the labour hours a family member spent on cooking in all villages of the respective environmental degradation condition divided by the total number of a family member in question, e.g. a wife, a husband or a schoolchild residing and working in that particular environment.

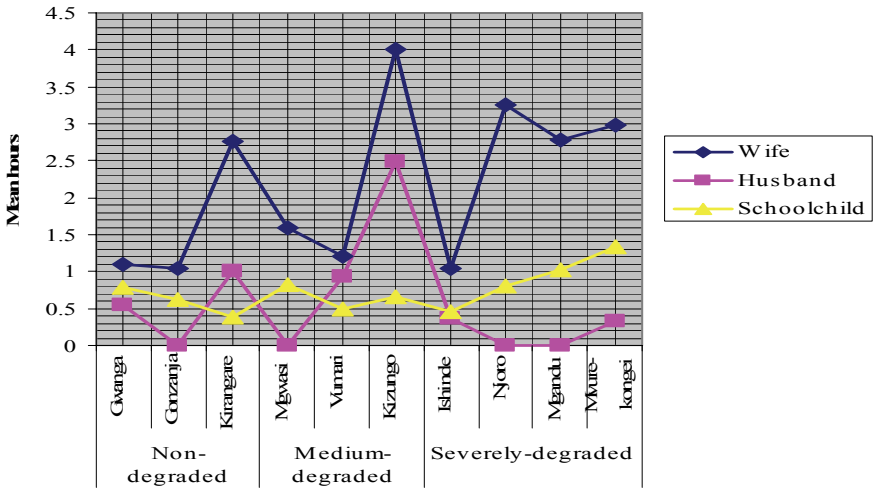


Figure 4.3. Mean hours spent daily on cooking by village and environmental condition.

There is not much difference in the outlook of Figures 4.2 and 4.3. This means that cooking is reflected in the housework labour where the wife takes precedence. On average, the wife spent 1 to 4 hours daily on cooking in different villages regardless of the environmental degradation situation. If we take into consideration the environmental degradation situation, then, the wife spent more time on cooking in the severely-degraded area than she spent in either the medium or non-degraded areas. The average time the wife spent on cooking in the severely-degraded area was 2.51 hours per day while in the medium and non-degraded areas she spent an average of 2.30 and 1.63 hours, respectively. Practically, the husband spent zero hours per day on cooking in the villages of Gonzanja, Mgwasi, Njoro and Mgandu which in total accounted 40 percent of the survey villages. In the other five villages[21] (that is, 50 percent of the survey villages), the husband hardly spent an hour on cooking. It was in Kizungo village only (that is, 10 percent of the survey villages) where the husband was reported an average of 2.48 hours in cooking. Regarding average time per day used in cooking with respect to the environmental degradation, the husband gave a complete different picture than both the wife and the schoolchild. The husband spent more time in the medium-degraded area (1.70 hours) than he did in the severely-degraded area (0.37 hours) and in the non-degraded area (0.71 hours), respectively. The schoolchild, on the other hand, did cooking in all of the survey villages. However, the schoolchild's participation in cooking per day was limited to a maximum of one hour in nine of the ten survey villages (that is, 90 percent). It was in Mvure-kongei village only that the schoolchild spent an average of over one hour (1.33 hours) in a day on cooking. Like the mother, the schoolchild spent more time on cooking in the severely-degraded environment than in the other two environments. The average cooking time the schoolchild spent per day with respect to the environmental degradation was 0.90 hours in the severely-degraded area, 0.67 hours in the medium-degraded place and 0.60 hours in the non-degraded environment.

[21] Gwangá, Kirangare, Vumari, Ishinde, and Mvure-kongei villages.

4.4. Model specification and estimation techniques

We examine the influence of time (T_a, T_m) spent collecting scarce environmental products (P_a, P_m) on both agricultural and household production (Y_a, Y_m). Starting with agricultural production, we consider the effects of time available for agriculture, collection of scarce environmental products and/or grazing (T_a), and other inputs in agricultural production processes such as the size of land in acres cultivated (P_{al}), agricultural market-priced inputs (P_a), and livestock inputs (K) as factors responsible for production. Basically, this refers to equation (3) of the theoretical framework.

With regard to household production, we take the effects of time (T_m), environmental goods used as inputs to the meal production process such as water and fuel wood (P_m), and agricultural goods used in producing meals, that is, rice, millet, beans and maize (Y_{am}) as factors responsible for domestic production. This refers to equation (2) of the theoretical framework.

Equations (2) and (3) imply a system of simultaneous household demand equations that are functions of all exogenous and endogenous variables. To each equation we add two variables; namely, environmental degradation (E) and household income (I).

Environmental degradation (E) is added to the equations because, together with the time variable (T), it measures resource scarcity. Assuming the ceteris paribus condition, poor environmental quality implies more time (T) spent on environmental product collection, less time in both agricultural and household production and thus lower production (Y). Alternatively, good environmental quality implies less time (T) spent on collection, and more time on production processes leading to higher output (Y). Environmental degradation is specified in dummy variables, with the non-degraded environment being taken as a reference or base category. The dummy coefficients are expected to increase with the severity of environmental degradation.

Household income, inter alia, includes both the wife's and the husband's labour payments W^w, W^h (if they are employed), pensions, grants, presents, and the sales from their agricultural produce, but excludes the monetary value of the domestic consumption from own agricultural produce. The exclusion of monetary value of the domestic consumption in household income is done to avoid the problem of double counting in the same equation.

Moreover, to both equations (2) and (3), a vector of household characteristics (Z) such as age, education level, occupation and household size will be added whenever deemed necessary and meaningful. Furthermore, because of the intertwined relationship between household production and household consumption, the household consumption of meals variable Y_m will be added to the agricultural production equation as an influential factor to agricultural output-demand (3), and likewise, the crop output variable Y_a will affect household consumption, and it is therefore added to the consumption equation (2).

We fit the empirical specifications using the Cobb-Douglas production function. The Cobb-Douglas production function is commonly used in economic analysis. It measures the output elasticity of one variable holding the other variables of the equation constant (Dowling, 1980). The logarithmic transformation of the Cobb-Douglas production function provides a log-linear form which is convenient and commonly used in econometric analyses using linear regression techniques (Wolkowitz, 1971). The log-linear equations as counter part of equation (3) and (2) ,in that order, can be specified as:

$$\log Y_a = \alpha_{1_j} + \alpha_{2_j} \log Y_{m_\tau} + \sum_i \alpha_{3_i} \log T_{a_i} + \alpha_4 \log I + \alpha_5 \log P_{al} + \alpha_6 \log P_a + \alpha_7 K + \alpha_8 E + \varepsilon \quad (14)$$

$$\log Y_m = \beta_1 + \beta_2 \log Y_a + \sum_i \beta_{3_i} \log T_{m_i} + \beta_4 \log I + \beta_5 \log P_m + \beta_6 E + \beta_7 Z + \beta_8 E * \log I + u \quad (15)$$

where:

Y_a is agricultural outputs in total monetary value of kilograms per year, i denotes the household member (1= husband; 2= wife; 3= schoolchild). We combine both schoolgirl and schoolboy time together into one variable because the descriptive statistics above show that they both, regardless of their gender, contribute nearly equally in all environmental conditions and in all households surveyed. For regression and interpretation purposes, we combine the outputs of the four survey crops together to obtain the total annual output that each household harvested for the agricultural year 2005/6. The same summing technique is used for the cropped-land size. We are forced to sum-up because the survey crops are intercropped on one and the same field, thus, it is difficult to quantify the labour force, *proxied* by the work hours, applied to each crop separately. Consequently, since the crop outputs weigh differently, we opted to use the monetary value of their yields as a common scale in the regression equation. This, however, does not alter the interpretation of the results.

Y_m denotes household consumption in caloric contents of all food taken during household meals. In the estimation we take the logarithm of total caloric intake from consumption of various meals in the household prepared from the harvested survey crops. In computing the caloric consumption[22], it is assumed that the total food consumed is made up of individual types of food j (j=1=maize; 2= beans; 3= millet and 4= rice). These individual food types are taken to be homogenous, so that a kilogram of food j contains a constant amount of calories[23] k_j (Subramanian and Deaton, 1996; *see also* www.fatfreekitchen.com/calories.html). Total caloric intake Y_m is then given by $Y_m = \sum_j q_j k_j$ where q_j is the total quantity of household consumption of food j.

The *general* regressands for the two equations are the respective time inputs measured in hours per week[24] T_a, T_m, total household income I excluding own domestic consumption, and environmental quality E. The endogenous variables are agricultural outputs in kilograms Y_a, *proxied* by their monetary values, and the consumption of the same Y_m, *proxied* by the caloric intake equivalence. The *specific* regressands for equation (14) are size of land in acres P_{al}; agricultural market-priced inputs P_a represented by tractor hiring and fertilizer use; and livestock inputs K, that is, ox-plough (dummy, equals 1if the household keeps livestock, zero elsewhere). The other *specific* regressand is the family size.

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[22] The formula for computing the caloric intake is hereby explained.

[23] The amount of Calories in each survey crop per 100 grams are: Maize flour (355 Calories), Rice (325 Calories), and beans (26 Calories). Note that, 1 kilocalorie = 1000 calories = 1 Calorie [1 Cal] = 4.18 kilojoules [kJ]. Computations were made to obtain the number of Calories in each kilogram of food j.

[24] We used the recall method and limit the recall period to one typical day for most of the routine collection and household activities. The data collected was then extrapolated to represent the period of one week. In the case of agriculture, recall was accomplished after the harvest. Because the recall period here extended over several months, some in-depth informal discussions and comparison with other semi-arid areas in the country were done to countercheck the validity of responses.

Fertilizer may either be a market-priced input if referred to inorganic manure purchased at a monetary price from the agricultural implement shops or a nonmarket-priced input if referred to organic manure collected at an opportunity cost from the animal stables within the vicinity of the households. The *specific* regressands for equation (15) are the environmental goods used as inputs to the meal production process (P_m) represented by the total volumes of water in litres and fuel woods in kilograms that the household demands per week for household production. Other *specific* regressands include the household size and the interaction terms. In equation (15), the interaction terms are the environmental degradation conditions times the logarithm of the total household income. The interaction terms are included to test whether the effects of each are influenced by the level of the other.

The caloric intake Y_m is instrumented with factors excluded from equation (15). The instrumented factors are the total size of land in acres, the fertilizer and the ox-plough use. On the other hand, the agricultural output variable Y_a is likewise instrumented with other factors excluded from equation (14). The factors for Y_a are the meal times per day in each survey household and the labour time each household member spends on housework chores. While α_1 and β_1 are constants, α_2 to α_9 and β_2 to β_7 are the parameters to be estimated. ε and u are the error terms that summarize all unobservable variables influencing agricultural outputs per year and the caloric intake demand[25] per day, respectively.

The cross-sectional demands in equations (14) and (15) are therefore estimated with two-stage least squares (2SLS) to control for the endogeneity of production and consumption within households. We obtain the parameter estimates in two steps, both of which are estimated by least squares. In the first step, the reduced form is estimated by OLS (that is, a regression of the endogenous regressors upon all instruments). In the second step, the original structural equations are estimated by OLS, while replacing all endogenous variables on the right hand side with the predicted values from the reduced form. In Section 4.5, we present the estimation results of both steps. However, our interpretation and discussion will be based on the second step results. The first-step results will be revisited whenever it is deemed necessary.

Viewed as a system of equations, our model has two endogenous variables, total monetary value of the agricultural outputs, Y_a, and the total caloric intake consumed of these examined agricultural outputs, Y_m. The model is simultaneous because Y_a appears on the right-hand side of the consumption equation (household production) and Y_m appears on the right-hand side of the demand driven-agricultural production equation.

4.5. Estimation results and discussion

4.5.1. Agricultural production

Table 4.8a shows the results of the two-stage least-squares estimation of the agricultural production equation. The table indicates how agricultural output of the four examined cereal staple-food crops is significantly related to consumption of these crops *proxied* by the total caloric intake, environmental degradation conditions, total cropped land, fertilizer

[25] The caloric intake demand and calorie consumption are used synonymously in this work. Note also that the logarithmic transformation is employed to the variable to remove skewness in the distributions and nonlinearity in the relationship.

application, ox-plough use and total household income accrued from other sources apart from the monetary value of their own-domestic consumption.

The first-stage regression results (upper part of Table 4.8a) suggest that the meal times per day in each survey household and the labour time the schoolchild spent on housework chores as excluded instruments were highly correlated with the caloric-intake demand, Y_m. Conditioning on other factors included in the equation, Y_m seems to play an important role in determining the agricultural production. The other coefficient estimates also agree with the prediction of the theory and empirical findings. We computed the test for over-identifying restrictions to assure that the instruments for Y_m are appropriately uncorrelated with the disturbance process. Table 4.8b gives the Sargan and Basmann tests of over-identifying restrictions. The tests accept the null hypothesis that the instruments were uncorrelated with the error term ($p \succ 0.000$ *i.e.* $p - value = 0.8296$ *and* 0.8393 *respectively*) and suggest that we should be satisfied with this specification of the equation and proceed with the interpretation (see Sargan, 1958; Basmann, 1960; Baum 2006 pp. 191-194).

The second-stage regression results show that caloric intake, the environmental degradation situation, fertilizer application, ox-plough use, cropped-land size, and family size separately influenced the agricultural output. While increases in land degradation, fertilizer, oxen, land area, and household size increased output; consumption decreased it. Each of these effects are discussed below.

Table 4.8a. Estimation results: Two-stage-Least Squares: Dependent variable: total crop output harvested proxied by its monetary value in Tsh.

First – stage regressions: (caloric intake = # household meal times, domestic work hours of schoolchild)		
Variable	**Coefficient**	**Standard error**
medium-degraded dummy[c]	0.10	0.04**
severely-degraded dummy[c]	0.11	0.04***
Log cropped land size	0.21	0.06***
Tractor application dummy (yes = 1)	-0.02	0.04
Fertilizer use dummy (yes = 1)	-0.04	0.03
Ox-plough dummy (yes = 1)	-0.01	0.06
Log # hours by husband per week	-0.04[a]	0.09[a]
Zero hours of husband	-0.19[b]	0.17[b]
Log # hours by wife per week	-0.15[a]	0.11[a]
Zero hours of wife	-0.26[b]	0.23[b]
Log # hours by schoolchild per week	-0.15[a]	0.07**[a]
Zero hours of schoolchild	-0.27[b]	0.09***[b]
Log total annual household income in Tshs.[e]	0.03[a]	0.01**[a]
Zero household income	0.07[b]	0.04**[b]
Log household size	0.59	0.09***
Log # domestic work hours of schoolchild	-0.14[a]	0.07**
Zero domestic work hours of schoolchild	-0.27[b]	0.09***
# household meal times per day	-0.13	0.03***
Constant	4.27	0.17***
Prob > F	0.0000	
R-squared	0.3696	
Adjusted R^2	0.3289	
Root MSE	0.1721	
Second –stage regressions, i.e., Instrumental variables (2SLS) regression		
Variable	**Coefficient**	**Standard error**
Log total calorie-intake (kCal/day/household)[d]	-0.76	0.32**
medium-degraded dummy[c]	0.53	0.07***
severely-degraded dummy[c]	0.61	0.07***
Log cropped land size	0.67	0.12***
Tractor application dummy (yes = 1)	-0.03	0.06
Fertilizer use dummy (yes = 1)	0.15	0.06**
Ox plough dummy (yes = 1)	0.40	0.10***
Log # hours by husband per week	0.13[a]	0.16
Zero hours of husband	0.07[b]	0.31
Log # hours by wife per week	0.01[a]	0.20
Zero hours of wife	0.15[b]	0.42
Log # hours by schoolchild per week	-0.14[a]	0.13
Zero hours of schoolchild	-0.21[b]	0.19
Log total annual household income in Tshs.[e]	-0.02[a]	0.02
Zero annual household income in Tshs.	-0.15[b]	0.07**
Log household size	0.88	0.26**
constant	3.96	1.25***
Prob > F	0.0000	
R-squared	0.4912	
Adjusted R^2	0.4623	
Root MSE	0.3131	
N	301	

Legend:

- Because of the zero hours (or zero income) if either a husband or a wife or a schoolchild did not participate in agricultural work (or if the household did not have income); then the following technique was applied:
  [a] (Dummy x log (hours), or (Dummy x log (income))
  [b] (1 – Dummy)
  Where if not observed log (hours) or log (income) = 0. Dummy = 1 if husband/ wife/child was farming (or if the household had income) and 0 if else.
- $*P<.1$, $**P<.05$, $***P<.01$
- [c] = reference category: Non-degraded.
- [d] = efforts were done to convert the total caloric intake per week per household and re-run the regression. The estimation results were exactly the same as reported here, but the only affected item was the value of the constant term whose coefficient, standard error and t-statistics changed slightly though still significant.
- [e] = income , as defined in the text, is the total household income from all sources minus the monetary value of the home consumption of the survey crops so as to avoid double counting.

Table 4.8b. Tests of over identifying restrictions for the equations used in the model

Sargan N*R-sq test	0.374	Chi-sq(2)	P-value = 0.8296
Basmann test	0.350	Chi-sq(2)	P-value = 0.8393

The direct elasticity of demand with respect to the caloric intake was significant at the 5 percent level and was less than one (0.76). This means that the quantity demanded of the cereal crops produced was not very responsive to changes in consumption of the same, probably because some of the produce was sold. The survey crops, especially in the lowland, are used both for food and for cash. Households are careful in their consumption because any excess use would imply a turn-away of efforts of some family members into alternative finance-seeking activities to meet the household-cash demand. The sign of the caloric-intake variable is negative, supporting the idea that an increase in consumption would inevitably affect the agricultural production negatively.

Furthermore, the results show that fertilizer use and ox-plough effects are both positive and highly significant. As expected, their application increased the cereals production in the area. An increase in the household size had a positive effect on output. In South Pare, human labour using a hand hoe is the basic level of agricultural mechanization. An increase in family size would supply extra human power to advance the size of the cropped land which would, in turn, increase the output, ceteris paribus.

The results in Table 4.8a further shows that staples production in the area was highly responsive to the cropped area, which was as expected. As the peasants increased the cropped-land size, also crop production increased, ceteris paribus.

The most interesting results concern the impact of environmental degradation on agricultural output. As expected, the results are highly significant, but to our surprise, favour severity of environmental degradation. Technically, the estimates suggest that as the environment becomes either medium or severely-degraded, the agricultural production increases. This is a paradox because from the theoretical framework we expected the opposite to be true. A logical understanding of the estimates, however, was given in the data descriptive part (Section 4.3), showing that the survey crops (maize, beans, millet and paddy) are cereals, which biologically yield better in either lowland or medium plateau land than at high altitudes where the environment is non-degraded (Maghimbi, 2007).

The results further show that the time each household member spent in agriculture had no significant effect on agricultural production. The results implicitly suggest that it does not matter how long one works on the impoverished field with traditional hand tools, but of importance are factors like how mechanized agriculture is, the size of the cultivated land and the state of environmental degradation that may either boost up or boost down the production. Several attempts were made to incorporate environmental product collection and/or grazing time by household members in the regression analysis but, for this sample, they proved insignificant. Though statistically the time spent on collection of scarce environmental products and/or grazing reduced agricultural labour, econometrically, agricultural labour would not significantly boost up output under the prevailing environmental conditions no matter how many extra hours the family members would spend on agriculture. As Shetto (2005) noted, human labour *proxied by* the work hours, is further limited by health, diet and environmental conditions. Under the tropical heat, a healthy adult using a hand hoe can hardly cultivate a substantial piece of land in a season. Shetto (2005) argued that a healthy individual with a simple hand hoe can work about 0.5

ha per season thus limiting the area under cultivation to 2 ha only for an average family of four adults; a household owning a pair of draught animals can manage 5 – 8 ha per season while a family that uses a 60-70 hose power tractor can manage more than 80 ha in a season. Therefore the adoption and the effective use of higher levels of mechanization such as animal traction and mechanical power is essential in increasing the cropped area and thus increasing production (if the cropped area is well managed).

Household income does not have a significant effect on agricultural output. However, it does play a significant role on the consumption of the survey crops as it is reported in the first-stage regression (see upper part of Table 4.8a). This means that household income increases the consumption of the survey crops. This is especially true for the households in the non-degraded environment (upland-plateau zone) where the survey crops normally do not perform well, yet the households rely on them. Since the climate in the upland-plateau zone favours the cultivation of other cash crops like coffee, the income from the sales of coffee may partly be used to buy the survey crops from the market and thus increasing their consumption.

4.5.2. Household production

Table 4.9a shows the results of the two-stage least-squares estimation of the household production equation. The first-stage regression result (upper part of Table 4.9a) suggests that the total size of land in acres, fertilizer and ox-plough use, as excluded instruments in the second stage, are highly correlated with the survey crop production. Conditioning on the other factors included in the equation, the survey crops (or their monetary value) do play an important role in determining the caloric intake. The over-identifying restrictions tests[26] also, acknowledge that the instruments are uncorrelated with the error term and suggest we should be content with the equation specification.

[26]See table 4.9b.

Table 4.9a. Estimation results: Two-stage-Least Squares: Dependent variable: total caloric intake (kCal/day/household)[d]

First – stage regressions: (monetary value of total crop output =cropped-land size, fertilizer application, ox-plough)		
Variable	**Coefficient**	**Standard error**
medium-degraded dummy[c]	0.58	0.08***
severely-degraded dummy[c]	0.69	0.12***
Log total annual household income in Tshs.[e]	-0.02[a]	0.05[a]
Zero annual household income in Tshs.	-0.15[b]	0.12[b]
Interaction term (medium-degraded*total annual household income in Tshs.	-0.03[a]	0.06[a]
Interaction term (medium-degraded*zero annual household income in Tshs.	-0.10[b]	0.15[b]
Interaction term (severely-degraded*total annual household income in Tshs.	-0.03[a]	0.06[a]
Interaction term (severely-degraded*zero annual household income in Tshs.	-0.08[b]	0.16[b]
Log household size	0.27	0.16
Log # hours on cooking by wife, husband and schoolchild per week (aggregate cooking time)	-0.03[a]	0.12[a]
Zero hours on cooking by wife, husband and schoolchild per week (aggregate cooking time)	0.04[b]	0.17[b]
Log household water in litres per week	0.14	0.10
Log household fuel wood in kilograms per week	0.32	0.09***
Log cropped land size	0.53	0.09***
Fertilizer use dummy (yes = 1)	0.10	0.06*
Ox-plough dummy (yes = 1)	0.41	0.09***
constant	0.69	0.40*
Prob > F	0.0000	
R-squared	0.5736	
Adjusted R^2	0.5493	
Root MSE	0.2866	

Second - stage regressions, i.e., Instrumental variables (2SLS) regression		
Variable	**Coefficient**	**Standard error**
monetary value of total crop output harvested	0.22	0.08***
medium-degraded dummy[c]	-0.23	0.06***
severely-degraded dummy[c]	-0.06	0.09
Log total annual household income in Tshs.[e]	-0.09[a]	0.03***[a]
Zero annual household income in Tshs.	-0.25[b]	0.08***[b]
Interaction term (medium-degraded*total annual household income in Tshs.	0.16[a]	0.04***[a]
Interaction term (medium-degraded*zero annual household income in Tshs.	0.51[b]	0.10***[b]
Interaction term (severely-degraded*total annual household income in Tshs.	0.18[a]	0.04***[a]
Interaction term (severely-degraded*zero annual household income in Tshs.	0.54[b]	0.11***[b]
Log household size	0.53	0.11***
Log # hours on cooking by wife, husband and schoolchild per week (aggregate cooking time)	-0.02[a]	0.08[a]
Zero hours on cooking by wife, husband and schoolchild per week (aggregate cooking time)	-0.08[b]	0.11[b]
Log household water in litres per week	0.05	0.07
Log household fuel wood in kilograms per week	-0.11	0.06*
constant	2.59	0.28***
Prob > F	0.0000	
R-squared	0.1878	
Adjusted R^2	0.1476	
Root MSE	0.1940	

Legend:

- Because of the zero hours if either a household has income, then the following technique was applied:
  [a] (Dummy x log (hours))
  [b] (1 – Dummy)
  Where if not observed log (hours) = 0. Dummy = 1 if a household has income and 0 if else.
- * $P < .1$, ** $P < .05$, *** $P < .01$
- [c] = reference category: Non-degraded.
- [d] = efforts were done to convert the total caloric intake per week per household and re-run the regression. The estimation results were exactly the same as reported here, but the only affected item was the value of the constant term whose coefficient, standard error and t-statistics changed slightly though still significant.
- [e] = income , as defined in the text, is the total household income from all sources minus the monetary value of the home consumption of the survey crops so as to avoid double counting.

Table 4.9b. Tests of over identifying restrictions for the equations used in the model

Sargan N*R-sq test	P-value = 0.0144
Basmann test	P-value = 0.0163

The second-stage results indicate that consumption of the survey crops, *proxied by* caloric intake, is significantly related to agricultural output, environmental degradation, household income, interactions of degraded environment conditions and household income (reference category is the non-degraded environment), and household size.

The survey crop output, a proxy for agricultural production, has a significant positive effect on the caloric intake from the consumption of the same selected dietary staples. This result implies that consumption tracks production. However, the elasticity of total consumption with respect to the gross value of the survey crops is equal to 0.22 suggesting that, around the mean of the dietary staples production, a one percent increase in cereal crop production would lead to a small increase in their consumption of only 0.22 percent. The other produce is either sold to meet the household cash demand as proposed earlier, or is stocked for precautionary purposes pending for the next harvest. Since geographically the survey crops grow relatively well in the medium and lowlands where there are no alternative cash crops, and the economy itself is subsistence with less stocks, we tend to believe that much of the produce is sold to cater for the household's financial expenditures. Our belief is supported with the statistically significant negative sign of the income parameter, suggesting that more consumption means less income.

The household income, especially in the medium and the lowland areas, comes mainly from the sales of agricultural produce of the survey crops. Income from other sources like remittances, grants, pensions and presents are limited and an insignificant number of families have reported to have ever received them. Most of the adult rural-Pare inhabitants were never formally employed in the past, so they were not entitled to pension. Moreover, the government of Tanzania does not provide subsidies to farmers. The little the rural people get may be in the form of presents at some peak occasions such as Christmas and new year festivals from family members who might have migrated to big towns in search of petty business and/or collar jobs. The rural-Pare peasants therefore, have to rely on the sale of their harvests for income. This is the subsistence economy. If peasants sell less of the produce, they earn less income and consume more. Otherwise, they sell more, get much income and remain with less food to consume. On the other hand, peasants from the upland-plateau area may not be concerned with the negative relationship between income and consumption because the major source of their income is not the sale of survey crops but the sale of cash crops like coffee in which we would expect a positive relationship. That is, the income from coffee sales would be used to buy the survey crops and increase their consumption.

The interactions of the environmental degradation situations and household income (the categorical reference is the non-degraded environment) are also significant and positive, suggesting that the consumption level of the survey crops was influenced by the combined effects of environmental degradation and household income.

The other positive effect is on household size. As household size increases, consumption also increases because of more mouths to feed.

4.6. Conclusion

The area described in this analysis is typical of South Pare, which is characterized by low levels of agricultural production, limited adoption of new technology, and high rate of natural resource degradation, particularly deforestation. Soil erosion was also noticed in

Semgalawe (1998) and Semgalawe and Folmer (2000). Both descriptive statistics and regression results indicate that overall there are strong possibilities that environmental degradation (deforestation) is limiting the production and consumption potentials in the area and that limited adoption of agricultural modernization further aggravates this problem.

Despite the fact that scarce environmental products collection and/or grazing reduced agricultural and domestic labour, assuming technology is constant, their effect in South Pare is minimized. Much weight, instead, is put on backwardness of the agricultural system and the state of the environment where agriculture is practiced. Though statistically insignificant, the agricultural and household time variables in all respects are positive, suggesting that had agricultural modernization been in place and the environment favourable then extra labour force in terms of additional work hours would have contributed positively to both production and consumption of the selected crops. In this regard, strategies for minimization of environmental products collection and/or grazing time so as to release more time for agricultural and household production are favoured and cannot completely be ignored.

Strategies designed to preserve the natural resource base would be recommended in view of long-run benefits. Short-run strategies would include campaigning for fuel wood energy-saving stoves, improving production technologies and persuading household members to grow drought-resistant crops like sorghum, cassava and sweet potatoes. Consequently, household members should change their consumption behaviour of eating certain preferable staples into alternatives that have a better chance of being produced. The long-run and much so, the short-run strategies should be carried out locally. Moreover, the strategies should be aimed at small farmers, who are nutritionally at risk.

CHAPTER 5

DETERIORATING ENVIRONMENTAL RESOURCES AND PRIMARY SCHOOL EDUCATIONAL ATTAINMENT

5.1. Introduction

This chapter tests Hypothesis 3, stating that school attendance and progress of children in rural primary schools, with respect to their gender, is inversely affected by deteriorating environmental resources.

In the preceding chapters we showed that schoolchildren were involved in the work, supporting their households' livelihoods, including housework, farming, collecting scarce environmental products and/or grazing. This type of child labour frequently leads to foregone schooling, which may have critical consequences for educational achievements. Understanding more about this form of child labour in the face of various degrees of environmental degradation, and its link to educational attainments is important. Tanzania, at the national level, has been struggling to improve educational attainments at the primary level. For example, the direct costs of schooling in primary schools are highly subsidized by the government with the intention of reducing the financial burden of low-income households in sending their children to school (Mason and Khandker, 1996). Yet, in general, Tanzania still remains far from its goal of universal primary education. In 1993, for example, primary school gross enrolment rates (GER) averaged 82 percent, approximately 10 percentage points lower than those reported in 1980. Delayed school enrolment by children is becoming more common in Tanzania. Although the official age at primary school enrolment is 7 years, the average starting age is over 9 years of age (Mason and Khandker, 1996).

While there are a number of factors that may affect attendance and school progress at the primary level, the question of how important children's work is in determining whether or not they attend school and attain desired progress at school remains. This chapter attempts to consider this factor as far as it results from environmental degradation in South Pare. Its main objective is to look at the role of environmental degradation on children's education in the rural South Pare highlands. To achieve this, it examines patterns of children's time use and analyses the extent to which the opportunity costs of children's time influences their attendance and progress at school.

The chapter is organized as follows: Section 5.2 offers a literature review on environmental degradation and children's education. The model specification for this problem is presented in Section 5.3. This is followed by the descriptive data analysis in Section 5.4. Section 5.5 discusses the estimation techniques we employ in the regressions. The estimation results and discussions are offered in Section 5.6. The chapter concludes with Section 5.7.

5.2. Environmental degradation and children's education: A review

Child labour literature surveys show that children in Africa have higher labour force participation rates than children in any other part of the world (Grootaert and Patrinos1999,

Canagarajah and Coulombe 1997). Theories of human capital (Becker 1993b, Mincer 1974) show that children's allocation of time to work or to school has long-term implications for the children's future ability to contribute to economic growth and development as well as to their economic status. Therefore, children's time allocation choices have long-term implications for economic development of African countries, particularly the less-developed sub-Saharan Africa including Tanzania.

Most of the analysis of child labour and schooling has been conducted on the effects of formal child labour on education. Some examples of these studies include Rosenzweig and Evenson (1977), Psacharopoulos and Arriagada (1989), and Psacharopoulos (1997). One of the welfare impacts of child labour is educational attainment. There is no general consensus on the negative effects of formal child labour on schooling. Some studies find that child labour is detrimental to schooling (Jensen and Nielsen 1997, Patrinos and Psacharopoulos 1997), while others find it not detrimental (Binder and Scrogin 1999) for school performance, and Skoufias (1994) finds a positive relationship between child wages and schooling.

However, in sub-Saharan Africa, it has been estimated that at least 95 percent of child labour takes place in private homes. Therefore, it is logical to include domestic child labour for household benefits in studying the welfare impacts of child labour. Few studies have quantified the effect of domestic child labour on schooling (Levison, et al. 2001, Ilahi 2001b, Levison and Moe, 1998). Lloyd and Gage-Brandon (1994) present results, suggesting that Ghanaian girls are disadvantaged due to their role in childcare responsibilities in large families, but children's labour was not modelled directly. Grootaert (1999) combined formal work and housework in her definition of child labour and found it to be negatively related to schooling in Côte d'Ivoire. However, domestic work was not modelled separately in the Grootaert (1999) study. Abler *et al*.(1998) studied the effects of formal as well as domestic work on children's education in Peru and found domestic work to be a greater deterrent to children's schooling than formal work. Binder and Scrogin (1999) found results contradicting Abler *et al*. (1998). Although both formal and household work[27] had a small negative impact on human capital formation hours (hours in school and extra-curricular activities), their main finding was that formal work is associated with reduced leisure for children. They also found that neither formal nor domestic work hours had significant negative effects on measures of academic performance (grades attained and child's desired schooling).

Gender-specific effects of work on schooling were reported in a study in Egypt by Assaad *et al*. (2001) and a study in Mexico by Levison *et al*. (2001). The Egyptian study found that girls' education was negatively affected by work when a broader definition of work was used to include domestic work[28], while boys' education was not. This study also shows that the way work is defined has a significant impact on the effects of child labour for girls, while for boys, a narrow definition of work to include only market work, does not change the effects of work on schooling. The Levison *et al*. (2001) study in Mexico found similar results: a broader definition of work resulted in girls' education being negatively affected by work, while a narrow definition (incorporating only market work) seemed to

[27] Their definition of children involved in household work includes those who performed household chores

[28] Their domestic work excluded firewood collection but included cooking, errands, house cleaning, collecting water, doing the laundry, and child care.

suggest that girls are advantaged in schooling opportunities. The study also found that presence of a mother was advantageous to both boys and girls but particularly to girls because they benefited more from the mother's role in doing domestic work.

Few studies have specifically looked at the effect of environmental degradation on children's education**.** However, some studies in the child labour literature can be interpreted as showing some evidence of the effects of the environment on education. For example, Psacharopoulos and Arriagada (1989) found that the existence of piped water was the strongest predictor of school enrolment in Brazil and that it also had substantial positive impact on school attainment levels (more years of schooling attained and reduced drop-out rates). Psacharopoulos and Arriagada (1989) took the availability of piped water as one of the proxies for the household's standard of living. However, this result can also be interpreted as evidence of the impact of environmental degradation on school attendance. That is, children who do not have a close source of water are disadvantaged in school enrolment as well as school performance. One explanation for this would be the greater amount of time that these children had to spend on water collection.[29]

The one available study that has specifically looked at the effect of environmental work on children's education is Nankhuni (2004)**.** Nankhuni (2004) investigates whether long hours of work spent by children in fuel wood and water collection activities, i.e., natural-resource collection work, influence the likelihood that a child aged 6–14 attends school. She applied two-stage conditional maximum likelihood on the data from the 1997–1998 Malawi Integrated Household Survey (IHS) conducted by the Malawi National Statistics Office (NSO) in conjunction with the International Food Policy Research Institute (IFPRI). The study finds that Malawian children are significantly involved in resource-collection work and their likelihood of attending school decreases with increased hours allocated to this work. The study further shows that girls spend more hours on resource-collection work and are less likely to attend school while burdened by this work. Consequently, girls may find it difficult to progress well at school. However, girls are not necessarily less likely to attend school. Results further show that the presence of more women in a household is associated with a lower burden of resource-collection work on children and a higher probability of children's school attendance. Finally, the research shows that children from the most environmentally degraded districts of central and Southern Malawi are less likely to attend school and relatively fewer of them have progressed to secondary school compared to those from districts in the north.

No such study like Nankhuni (2004) linking environmental degradation to children's education has been conducted in Tanzania. The three studies we have access to are Akabayashi and Psachropoulos (1999), Al-Samarrai and Tessa (1998), and Mason and Khandker (1996). The concerns of these studies were not, however, with the impact of environmental degradation on child schooling but with the related effects of formal labour on human capital formation in Tanzania.

Akabayashi and Psachropoulos (1999) investigated the degree of trade-off between child labour and human capital formation using time-log data of children from a Tanzanian household survey. They found that a trade-off between hours of work and study existed, and hours of work tended to be more affected by social conditions than hours of study.

[29] Psacharopoulos and Arriagada (1989) explain that this variable could also be reflecting location attributes, that is, communities with piped water are also likely to have more public schools and other social facilities.

Hours of work were negatively correlated to reading and mathematical skills through the reduction of human capital investment activities, indicating a trade-off between child labour and human capital. The results indicated the complexity of the issue and the need for detailed time allocation data.

Al-Samarrai and Tessa (1998) used multivariate regression techniques to analyze household survey data collected in rural Tanzania in 1992 in a joint research project by TADREG (Tanzania Development Research Group) and the University of Dar es Salaam. Al-Samarrai and Tessa (1998) focus on how household and individual characteristics affect whether or not a child goes to primary school, completes primary school and attends secondary school. The regression analysis shows substantial intra-household differences between the way in which household characteristics affect outcomes for boys and girls, and how mothers' and fathers' influence over resource decisions differentially affect outcomes. For example, when looking at the decision as to whether to enrol in primary school, the fathers' education has a greater influence on boys whereas the mothers' primary education has a greater influence on girls. Furthermore, married mothers' education can increase the probability of girls enrolling in secondary school by 9.7 per cent for primary education and a further 17.6 per cent for secondary, while having no significant effect on the enrolment of boys. These results imply that mothers have a relatively stronger preference for their daughters' education and that their education gives them either increased household decision-making power or increased economic status.

Mason and Khandker (1996) use the household data survey from Tanzania to analyze children's time use and to estimate the opportunity cost of children's time. The study also analyzes the determinants of school enrolment and late starting to clarify how child labour and the opportunity costs of children's time affect schooling outcomes. The results suggest that households are indeed sensitive to the opportunity costs of schooling. Both the female opportunity wage and distances to primary schools are found to be significant determinants of whether children enrol in school and whether they start on time. Constraints in the supply of primary schools also appear to play a significant role in child enrolment and late starting decisions, particularly with respect to girls. Parents' education levels also have an effect. In contrast, neither household income nor the direct costs of primary schooling appear to significantly affect enrolment or late starting at the primary level.

Our study seeks to contribute to the scant evidence on the effects of environmental child labour on children's education. It specifically looks at the role of environmental degradation on children's primary education in the rural South Pare highlands.

5.3. Model specification

5.3.1. Theoretical framework

At the household level, education can be viewed both as an *investment* and as *consumption* good (Al-Samarrai and Reilly, 2000).

Education is an *investment good* because parents invest in their children's education so that their children and grandchildren will have better life chances, and because they enjoy having literate and educated children. Parents also invest in their children's education to ensure that their offspring will be best placed to support them in later life (Al-Samarrai and Tessa 1998). A household production function approach has been widely adopted in the

literature to model school decisions made at the household level (see Tansel, 1993; Durasaimy, 1992; Strauss and Thomas, 1995; Glewwe, 2002). These models imply that there is an optimal investment in education for each child equating the present value of the expected marginal costs and benefits to the household. Costs are incurred throughout the duration of a child's schooling and include direct costs (e.g., school contributions and stationery) and the opportunity costs of a child's time (e.g., household work and farm activities foregone while at school). The benefits to the parents of educating their children depend on a number of factors, including the rate of expected remittances from their children when they leave home, the probability that their children will find work, and the time preferences of the household members. Although the optimal level of investment in education is determined by each household, the presence of constraints implies that the optimum amount of education may be unattainable. For example, the monetary costs of education are incurred before many of the monetary benefits are realized. Some households may not have the resources available to finance the initial costs of education for some or all of their children and, through lack of collateral, may be unable to borrow the necessary resources from capital markets. This implies that the educational attainment will be related to other household characteristics, such as household income and the levels of parental education.

Education can also be seen as a *consumption good***,** in that it can directly enhance parents' utility and there may also be non-monetary benefits to education for the acquiring child (i.e., the child's current utility may be enhanced by going to school, and also by not having to work). Schultz (1963) describes the consumption benefits of education as divisible into three components: an investment component which results in an increase in an individual's measured wealth; a present consumption component such as the utility currently derived, say, from attending class; and a future consumption component which results from the fact that education improves one's ability to consume other goods later in life. A considerable amount of research has been done on the use of education in non-market activities. Michael (1973a), for example, claims that more educated individuals consume other commodities, such as reading, more than their less-educated counterparts. Liebowitz (1974) finds that an increase in a mother's level of education is associated with a higher-measured intelligence quotient (IQ) for her child. In the area of family planning, Michael (1973b) has found that more educated individuals are better contraceptors and are less likely to experience an unwanted birth. Benham (1974) finds that an increase in a woman's education is associated with higher earnings on the part of her spouse, given his education. That is, an educated woman finds a higher earning spouse. These examples show that education is associated with many aspects of an individual's behaviour in addition to its impact on his earnings capacity.

When education is seen in this way, the households' preferences for educated children may be an important factor in the decision to send children to school or not. This is likely to be related to the level of education of the parents. Preferences for schooling of boys and girls are formed in the context of social and cultural norms, and it is likely that preferences will be gender specific and household attributes will have a differing impact on the schooling decision for boys and girls.

The above considerations suggest a number of explanatory variables that might influence primary school attainment. These variables include, *inter alia*, parental characteristics, household income levels, household size, cost of schooling in monetary and

opportunity terms, individual characteristics like gender and age, and location variables. Location variables include the status of environmental quality where the household is situated. Some of the studies[30] reviewed in Section 5.2 adopted such an approach in their analysis of primary schooling in Tanzania. Other studies[31] also preferred the same approach in their analysis of primary schooling elsewhere in Africa. However, these studies excluded the environmental degradation phenomenon.

We adopt this framework here but with an emphasis on exploring the effects of environmental quality status of the area where the household is situated. There is a fundamental reason why environmental degradation status could result in different education outcomes among schoolchildren. We think that schoolchildren in different environmental degradation situations may be victimized differently with regard to their time use patterns in different activities including scarce environmental product collection and/or grazing, farming and domestic work, which would result in poor school progress. A key issue, therefore, is to examine, *inter alia*, the extent to which variations in environmental degradation are explaining disparities in primary school progress.

5.3.2. Empirical specification

The variable indicating school progress in this study is referred to as "educational attainment" implying progressing at the right age for class. In the literature[32], one frequently used measure of school attainment when the sample is younger and still at school is SAGE (Schooling-for-Age or Grade-for-Age). SAGE is calculated using the procedure proposed by Patrinos and Psacharopoulos (1997) given as $Grade\text{-}for\text{-}age = 100^{*}\left[\frac{Grade\,or\,class}{Age - E}\right]$ where E represents the country-specific usual school entry age (which is seven years in Tanzania). SAGE will therefore measure school attainment relative to age. A score of less than 100 indicates that the child is falling behind in education. Consequently, all those with a score under 100 are considered as having below normal progress in the school system. The formula for SAGE as proposed by Patrinos and Psacharopoulos (1997) presents, however, several issues when using our data on young children. For children who are in their first year of schooling, a strict interpretation of SAGE will give an infinite value since the denominator equals zero (since Age – E = 0). Further, if a child starts school before he/she reaches the minimum age, then SAGE potentially can be greater than 100. In this case then, E = 7 cannot be used for the entire sample in constructing SAGE which automatically leads to loss of information. If E = 7 is used, then SAGE will take negative values for six year-old children, and infinite values for seven year-old children. For the purpose of estimation therefore, in our study, the formula for educational-attainment variable is modified into a discrete ordered variable, which is obtained using the following formula:

$$SAGE = (Grade\ or\ class - Age) + (E - 1)$$

Because the compulsory entry age in Tanzania is 7, the educational attainment formula becomes $SAGE = Grade - Age + 6$. It follows that if $SAGE = 0$ implies "on

[30] Akabayashi and Psachropoulos (1999), Al-Samarrai, and Tessa (1998), and Mason and Khandker (1996)
[31] Birdsall and Orivel (1996) for Mali, Lavy (1996) for Ghana, and Grootaert (1999) for Cote dÍvoire.
[32] Orazem et al.(2004), Khanam and Russell (2005), Maitra (2003) and Orazem and Gunnarsson (2003)

time" school progress; $SAGE > 0$ "ahead" of normal school progress; and $SAGE < 0$ indicates "falling behind".

The literature[33] also recognizes schoolchildren as producers and consumers of commodities who participate in household and agricultural production as well as in their own schooling and leisure. Schooling is a commodity whose grade attained $(SAGE)$ is subject to time allocated to education T_c, household characteristics that affect child education e.g. ethnicity Z_c, individual characteristics like gender, age, age squared, parents' educational level, occupation, etc. F_c, household income I, household size H, market-priced school goods G_c, environmental quality E, and the interactions[34]. The square of the age is included to account for any non-linear age effects. Equation (1) is proposed:

$$SAGE = c(T_c, Z_c, F_c, I, H_c, G_c, E, E * I) \qquad (1)$$

Where the subscript c is restricted to characteristics that affect school attainment exclusively.

The environmental quality E may affect the children's education through its effect on the productivity of time in the household production function. For instance, if the environment is more degraded, children will have to spend more time on environmental product collection and/or grazing at the cost of their schooling. That is, the number of hours that children spend on resource collection and/or grazing is associated with a reduced likelihood of school attendance, supporting the hypothesis of resource collection work having a negative influence on schooling.

Household size H is included in the specification to capture possible substitutes for child labour. Nankhuni (2004) observed that the presence of other active family members in the household is associated with fewer hours of resource collection work for schoolchildren. This suggests that a larger number of household members beyond school age help to relieve the work burden on school-age children and thus increase the probability of attending school. In the household size variable, we also include the gender of the members. We believe, as testified in the preceding chapters, that the number of women in the household increases the likelihood of children to attend school. This suggests that female household members, who are principally involved in household responsibilities, tend to reduce the burden of household work on school-age children. This effect was also observed in Côte d'Ivoire by Coulombe (1998), for girls in Peru by Levison and Moe (1998) and for girls in Egypt by Assaad et al. (2001). Likewise, adult males, who are principally responsible for grazing might reduce the burden of grazing on school-age children, especially boys, for those households that keep cattle, thus increasing children's school attendance.

Household characteristics Z_c also affect the likelihood of a child participating in natural resource collection work and the intensity of this work (Nankhuni 2004). Ethnicity, for example may influence the probability of whether a child of particular gender would progress well at school or not. Some tribes in Tanzania may not value the education of girls

[33] Mueller (1976) and Caldwell (1990).

[34] The interaction of the environmental degradation situations and the logarithm of the total household income. The reason for its inclusion is given in the text.

highly and therefore may not seriously invest in their human capital formation. The idea behind is that girls will get married and may shift to another clan. Investing in the education of girls, in this case, would benefit the would-be husband's clan. Schoolgirls originating from clans of this mentality may have a greater probability of working long hours collecting environmental products and/or grazing, performing domestic chores and working at fields as a sort of training for their physical capability of maintaining their would-be families once they get married.

No information on market-priced school goods G_c is reported in the data. As a result, the effects of direct cost of schooling is implicitly reflected in the household income variable I. A household may be forced to keep the children away from school because its income is close to the subsistence level (Jensen and Nielsen 1997). On the other hand, we expect that relatively wealthier households are less resource constrained in meeting direct school costs, which makes it easy for their children to attend school and probably progress at school. Connected to the household income is the interaction of the environmental degradation situations and the logarithm of the total household income. In the estimations, we include the interaction of the environmental degradation situations and the logarithm of the total household income to test whether the effects of household income are influenced by the level of environmental degradation, even in education regard. This interaction term, previously, had a significant impact on agricultural produce (see Chapter 4) which is, in fact, a major source of household income that we hereby propose to have an effect on the educational attainment of the schoolchild.

Excluded from the list of variables, although deemed desirable, is school quality. School quality data is unavailable from this survey. However, Nankhuni (2004), showed that children living in areas in Malawi where schools are relatively poorly stocked (as reflected by the number of school-age children per teacher) are not necessarily less likely to attend school, implying that school quality measured in this way may not be the most important issue in school attendance. However, we still believe that the variable might affect educational attainment in South Pare and its omission is regretted.

The familial relationship within the household is also considered. This is because we believe that familial relationship is posited to influence educational outcomes. Burke and Beegle (2004), for example, proved that children residing with their parents may face different outcomes than foster children and orphans. Foster children and orphans are potentially disadvantaged in many ways, although the evidence for this varies across countries (Ainsworth *et al*, 2002). Foster and orphan children have been found to lack proper nutrition, have less access to health care, work longer hours and receive less schooling than the family's own children (Ainsworth, 1996; Bledsoe *et al*., 1988). We control for foster and orphan status by selecting school-age children who live with their biological parents.

5.4. Descriptive statistics

We had a sample of 301 schoolchildren in our survey, one from each household. The criteria used for selection were primarily their familial relationship to the household head, their undoubted physical ability to perform various activities without difficulties, including collection and/or grazing and other agricultural and household work, were enrolled at primary schools and were able to express themselves. With regard to familial relationship,

we preferred children who were living together with their biological parents. Parents might suggest children to be interviewed, but the free willingness of the child to participate in the interview was most important. All children came from the households participating in the survey. Of these 301 schoolchildren, 152 (50.5 percent) were boys and 149 (49.5 percent) were girls. In general, 92 percent of these children reported that they attended school in the past 12 months while 8 percent reported they did not. The 8 percent who did not attend had either permanently or temporarily dropped out of school. In any case, if they would attend school next academic year they would have to repeat a grade. For those who attended school in the past 12 months, it happened that some missed school occassionally apart from allowed holidays and school breaks. 2 percent of the schoolchildren reported having missed school quite often, 75.4 percent missed school regularly and 22.6 percent never missed school during the whole academic year. The rainy season was reported as the period that schoolchildren most often missed school. 57.8 percent of the school-goers acknowledged having missed school quite often during the rainy season. 15.6 percent did not attend school most often during the dry season while 26.5 percent found the interview question not applicable suggesting that they either never missed school or seasonality had no direct connection with their school non-attendance.

There were several reasons explaining why they sometimes failed to attend school at the specified time. 40.5 percent cited illness as the major cause. 22.9 percent of the schoolchildren sometimes did not show up at school due to bad weather while 7 percent failed to come to school on some days because of collecting environmental products. Other causes were working at farms (3 percent), working at home (1.7 percent) and lack of stationery (3.7 percent). 20.9 percent of the schoolchildren respondents sometimes didn't attend due to 'other reasons'. We suspected this category might contain those not regularly attending school because of practicing petty trading in the street as the respondents were reluctant to admit the fact. Poor quality of some primary schools could also contribute to the problem of seasonal non-attendance though it was not questioned in the research instrument.

We did not find a significant difference in school attendance between girls and boys. Hours spent in collecting scarce environmental products and/or grazing, farming and domestic work, which might affect school attendance, did not differ significantly between boys and girls though gender bias prevailed for some activities like grazing for boys and housework, especially cooking, for girls (see Table 5.1).

All children specified their schools and respective classes. Ishinde primary school enrolled 10 percent of the survey schoolchildren. Other primary schools[35] enrolled between 0.3 percent to 9.6 percent of the survey schoolchildren. These primary schools were located at a distance from each other at different villages in different environmental degradation conditions. Pupils were enrolled at a nearby school from the homestead. Villages in this study each had at least one primary school. These facilities were public and children rarely attended primary schools outside their village. The distribution of children across different classes of education is presented in Figure 5.1. The majority of schoolchildren in the survey households were concentrated in classes 4 to 6. There were 33.6 percent, 21.9 percent and 16.6 percent in classes 6, 5 and 4, respectively. These were mature pupils and their physical

[35] These other primary schools are Mgwasi, Gwanga, Njoro, Mgandu, Gonzanya, Kirangare, Mongoloma, Mwanya, Marien, Ndivem, Emuguri, Majevu, Jitengeni, Mbono, Dido, Minyala, Changarawe, Kidundai, Kitala, Makasa, Maganda, Njagu, and Msasa.

labour force was essential in supporting their parents in agricultural activities, housework, collecting scarce environmental products and/or grazing. However, Class 7 pupils, though mature, might not be largely available as they were preparing themselves for the final examinations of accomplishing a 7-year primary school education. Their daily school schedules might also be very tight.

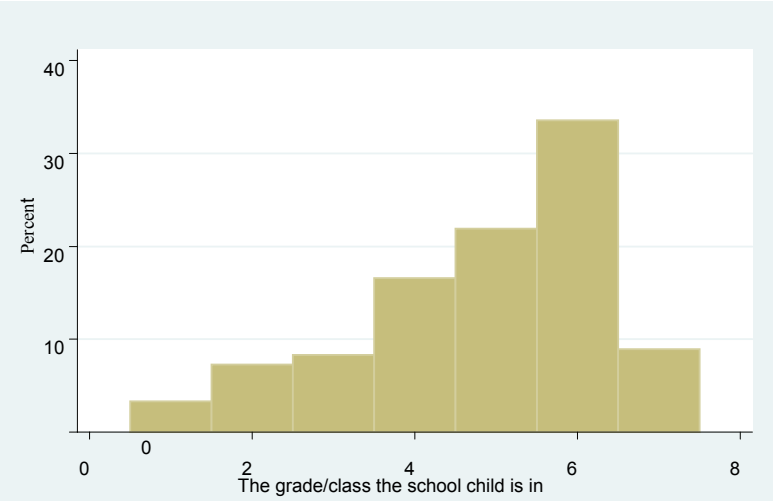


Figure 5.1. Distribution of children across classes.

Schooling might result in both direct and indirect costs. The direct costs of schooling were mainly costs of uniforms and costs of school equipment, mainly stationery. Other equipment like textbooks were usually provided by the government, pupils found them at school though still in short supply. In the study area, parents had no custom of buying textbooks for their children. Other direct costs like school fees and enrolment fees (introduced in 1995) were eliminated by the Tanzanian government in 2002 (Burke and Beegle, 2004). Because each village had at least one primary school, almost no children had transportation or lodging expenditures. Under the Primary Education Development Plan (PEDP) developed within the context of the Education Sector Development Programme (ESDP) covering the period 2002-2006, primary school fees and other parental contributions were abolished at primary level and capitation grants were raised with an ultimate target of US$ 10 per pupil (Mbelle and Katabaro 2003). Despite some allowable financial contributions for attending such expenditures like graduation festivals, direct costs of schooling were rather low in Tanzania (Burke and Beegle, 2004) and were not considered in our research instrument. Instead, we considered the indirect cost or rather the opportunity costs of schooling as the more relevant "cost" of schooling in our case. In particular, we focused on the hours pupils spent in school compared to hours in other activities. Since, by law, these pupils were prohibited to have formal employment, e.g. in government and private offices while still schooling, we considered formal employment activity as non-applicable and completely absent from the survey questionnaires. This, however, did not exclude the possibility that a few school pupils might have spent some time in non-farm self-employment in petty trading and similar businesses. However, this

aspect of non-farm self-employment was not considered in the research instrument. To cater for its possibility, Table 5.1 includes a non-explained time-spent variable.

We emphasized seven broad areas of time use for schoolchildren in our sample. These were water fetching, fuel wood collection, grazing, agricultural work, household chores, schoolwork and leisure. In this chapter, water fetching, fuel wood collection and grazing, as it was before in the text, are referred to as scarce environmental product collection and/or grazing works.

Table 5.1. Distribution of time per week by environmental condition

	Non-degraded		**Medium-degraded**		**Severely-degraded**	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Schoolboy						
Water fetching hours	5.04	2.54	6.16	4.49	11.24	8.71
Fuel wood collection hours	3.38	1.67	4.12	2.99	7.50	5.80
Grazing hours	2.35	2.26	3.60	3.40	6.13	6.77
Agriculture working hours	8.01	5.67	7.54	5.39	11.77	6.73
Household chores hours[a]	4.19	2.45	3.94	2.44	7.09	4.38
Leisure hours[b]	80.09	8.04	78.35	24.80	55.66	29.16
School hours[c]	60.60	3.31	60.34	12.35	61.33	4.62
Unaccounted-for hours[d]	4.34		3.93		7.28	
Total	**168**		**168**		**168**	
Schoolgirl						
Water fetching hours	4.93	2.18	6.02	3.78	8.74	6.79
Fuel wood collection hours	3.30	1.43	4.02	2.51	5.84	4.51
Grazing hours	1.90	2.02	2.61	2.83	3.90	4.80
Agriculture working hours	9.23	5.18	7.51	5.92	9.35	7.13
Household chores hours[a]	5.19	2.53	5.58	4.03	7.08	3.85
Leisure hours[c]	78.27	10.58	74.94	21.42	66.11	26.65
School hours[d]	59.88	5.56	61.94	9.27	60.04	10.00
Unaccounted-for hours[e]	5.30		5.38		6.94	
Total	**168**		**168**		**168**	

Legend: Std. Dev. – Standard Deviation

e. Household chores hours were the sum of the average hours each schoolchild in the above three categories spent per week on cleaning, cooking and childcare

f. Leisure hours were average hours available per week for ease and relaxation free from responsibilities.

g. School hours were average hours per week dedicated for education. This included time spent walking to and from school, time in school and time spent on school homework plus private studies at home.

h. Unaccounted-for hours referred to average non-explained time spent per week on any unforeseen activity including petty trading (street vendor) or the like-nature business.

Girls and boys spent, on average, the same number of hours per week in school activities in all environmental conditions. On average, they dedicated 60 hours per week on education. This included time spent walking to and from school, time in school and time spent on school homework plus private studies at home. There were some minor variations of time spent on other activities like collecting scarce environmental products and/or grazing, agriculture and household chores depending on the gender biased nature of the activity and the environment where the activity was taking place. Because of these slight variations of time use in other activities apart from education, we consequently notice some

variations in leisure hours per week amongst the genders. While boys had, on average, more leisure hours in both non-degraded and medium-degraded environments, they had less leisure hours in severely-degraded environments. Surprisingly, a cross-sectional check of time use per week on scarce environmental product collection and/or grazing activities reveals that households in all environmental conditions lose comparatively more hours worked when they sent boys to school than when they sent girls. Likewise, households in almost all environmental conditions (but especially in the non-degraded and the medium-degraded areas) lose comparatively more hours worked on household chores when they sent girls to school than when they sent boys. Reasons as to why boys spent relatively more time for grazing and fuel wood collection in all environmental conditions were clear because grazing predominantly was a male job and fuel wood, as already explained in previous chapters, was scarce even in the non-degraded environment due to reforestation programs accompanied with the prohibitive by-laws causing adult females to walk long distances to collect the stuff. For security reasons then, male children were preferred to accompany their female parents on the way to and from the open access. However, it is not clear why boys in comparison to girls spent more time in water-fetching activity in all environmental conditions. Probably the same protective role to and from the water source contributed to this realization as girls made themselves more available at home for domestic chores.

The time use profile presented in Table 5.1 was collected for schoolboys and schoolgirls in different cohorts between 6 and 19 years of age. Figure 5.2 shows the distribution of schoolchildren interviewed with respect to their age. Not surprisingly, as children got older, those who attended school tended to spend more time in school and on school work while those with tender ages might have not enough strength to offer required labour force in various examined activities. This explains the nearly normal distribution curve presented in Figure 5.2. The majority of the schoolchildren under survey were between 10 and 15 years old. This trend did not differ according to the child's gender.

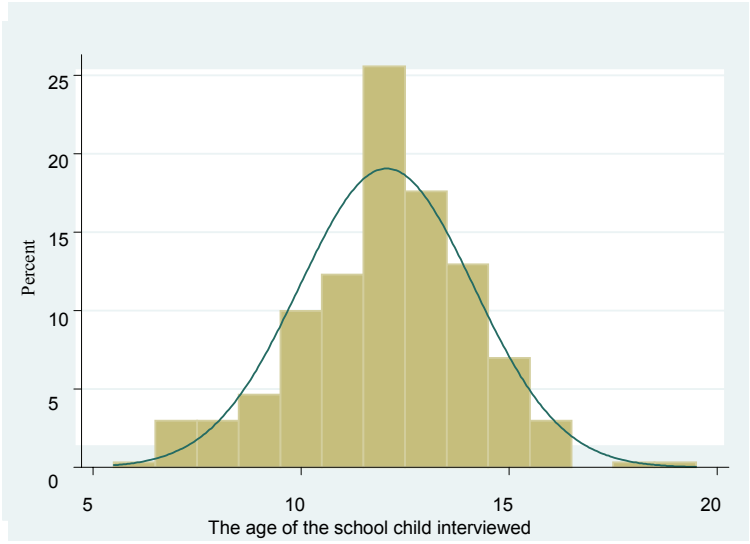


Figure 5.2. Age distribution of schoolchild

In defining child labour, the International Labour Organization (ILO, 1997a,b) considered a person as a child if he/she was under 14 years of age. For our analysis, we selected an age range of 6-19 years. The justification of taking this age cohort was as follows: According to the education system of Tanzania, children in the 15 – 19 years age range should be at the end of secondary school or at the beginning of higher secondary school (Al-Samarrai and Tessa 1998). However, the data suggests that there were some children in the 15 – 19 years age group who were still at primary school. It was not surprising for a country like Tanzania, where late enrolment, especially in rural areas, was common. Thus including children of 15 to 19 years old allowed us to consider late entry and grade repetition. Moreover, we observed several cases where children under 20 years old lived with their parents, except daughters who tended to join their husband's family after marriage. All schoolchildren aged 6-19 years included in this analysis had both their father and mother living together in the same house. This sample was part of the 88 percent of the children of various ages, educational and occupational backgrounds who still resided in the homestead as sons/daughters of their own parents. The remaining percentages, which were excluded in our analysis, were grand children (9.3 percent), adopted/step children (1.3 percent) and niece/nephew (1.4 percent) of household heads.

Likewise, although official enrolment age in Tanzania was 7 years, we still have a minimum age of 6 years in our data set because there were children who started school at age 6. For the estimation of child labour in agricultural, household, environmental product collection and/or grazing activities, 6 years old might be considered extreme. But it was common in rural Pare and elsewhere in the countryside for young children to participate. A survey by Bangladesh Institute of Development Studies (BIDS 1977-78), for instance, reports that the rural children in Bangladesh start their economically productive life from 5 years of age (Salauddin, 1981). Our data in rural Pare also shows that there was one boy of age 6 who combined school with other work. For primary school late entry cases, our data records 23.6 percent of the schoolchildren who started class 1 at the age of 8, 19.8 percent at the age 9, 4.3 percent at the age of 10 and 0.7 percent at the ages of 11 and 12 each, respectively. Our sample shows that only 51.2 percent of the attending schoolchildren started class 1 at the right age of 7 as required by the education system in Tanzania. The reasons of the late entry as stipulated by the pupils themselves are presented in Table 5.2.

Table 5.2. Reasons for primary school late entry

Reason	**Frequency**	**percent**
Illness	44	14.6
Work at home	15	5.0
Work on the farms	9	3.0
Collection environmental products and/or grazing	15	5.0
School crowded	60	19.9
Inability to meet direct school costs, e.g. school uniforms and stationery	4	1.3
Not applicable (entry on time)	154	51.2
Total	**301**	**100**

Table 5.2 shows that the main reasons for late entry are: school being crowded (19.9 percent), illness (14.6 percent), work at home (5.0 percent) and collecting scarce environmental product and/or grazing (5 percent).

5.5. Estimation strategy

SAGE, our dependent variable, is an ordinal variable, which indicates a ranking of school attainment. Since the values of such an ordered school progress are arbitrary and are a function of a set of explanatory factors as described in equation (1), we use ordered probit estimation techniques. The following specification is used:

$$C_i^* = \beta' z_i + \varepsilon_i, \quad \varepsilon \sim N(0,1), \quad i = 1,..., N. \qquad (2)$$

where C_i^* = the latent measure of educational attainment
z_i = a vector of explanatory variables describing the school attainment
β = a vector of parameters to be estimated, and
ε_i = a random error term (assumed to follow a standard normal distribution)

Figure 5.3 illustrates the correspondence between the latent, continuous underlying school attainment variable, C_i^*, and the observed educational progress, C_i.

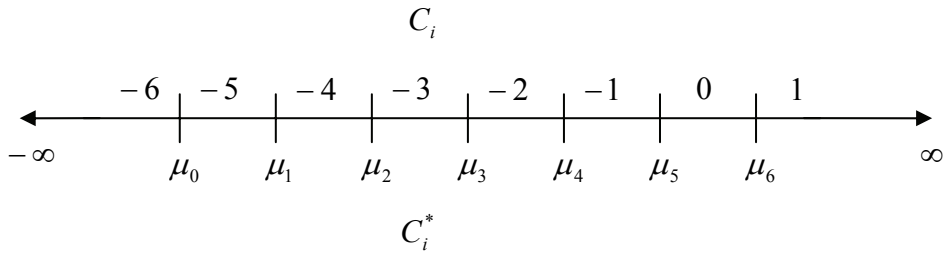


Figure 5.3. Relationship between latent and coded educational attainment variables.

The observed ordinal school attainment variable, C_i, takes on values of −6 through +1 in the following scheme:

$$C_i = j \Leftrightarrow \mu_{j-1} < C_i^* \leq \mu_{j,}$$

where $j = -6 \; through \; +1$. This range of values for j is derived by fitting the corresponding survey data in the educational attainment (*SAGE)* formula described earlier. The eldest schoolchild in our sample, aged 19 years old was in grade (class) 7; while the youngest schoolchild was 6 years old, being in grade 1. Employing the SAGE formula, we obtain −6 and +1, respectively.

In the pursuit of completeness, we define $\mu_{-1} = -\infty$, and $\mu_m = +\infty$. We are concerned with how changes in the predictors translated into the probability of observing a particular ordinal outcome in the range of −6 to +1.

Considering the probabilities of each ordinal outcome, the generic form is:

$$P[C_i = j] \quad = \quad \Phi(\mu_j - \beta' z_i) - \Phi(\mu_{j-1} - \beta' z_i)$$

For $j = m$ (the "highest" category), the generic form reduces to

$$P[C_i = m] = \Phi(\mu_m - \beta' z_i) - \Phi(\mu_{m-1} - \beta' z_i)$$
$$= 1 - \Phi(\mu_{m-1} - \beta' z_i).$$

Since $m = 1$, then

$$P[C_i = 1] = \Phi(\mu_1 - \beta' z_i) - \Phi(\mu_0 - \beta' z_i)$$
$$= 1 - \Phi(\mu_0 - \beta' z_i).$$

where i is a schoolchild and $\Phi(.)$ is the standard normal cumulative distribution function. The interpretation of this model's primary parameter set, β, is as follows: positive signs indicate higher school attainment as the value of the associated variables increase, while negative signs suggest the converse (see Greene 2000).

5.6. Estimation results and discussion

Three separate sets of results are given in the upper part of Table 5.3 for schoolgirls (Column 1), schoolboys (Column 2) and for the pooled regression including a gender dummy (Column 3). The lower part of Table 5.3 shows Greene's post-estimation parameterization which provides both the coefficient estimate and the standard error of the thresholds μ_i.

The probability of educational attainment at primary school, in all regressions, was found to be significantly associated with age, age-squared, and the mother's secondary education. The formal employment status of the mother being in a government office significantly affected the probability of educational attainment of both the schoolgirl and the schoolboy in different ways, but not in the pooled sample estimates. The household belonging to the Sambaa tribe, as compared to other tribes, significantly decreased the probability of schoolgirls progress at primary school. The basic literacy of the mother at the primary education level, cropped land size, and the interaction term of medium-degraded environment and household annual income increased, at a lower significance level, the probability that schoolboys would progress at school. Interestingly, in severely-degraded environments as compared with non-degraded areas, the probability of girls' progress at school was significantly lower. However, the environmental degradation situation neither had significant impact on schoolboys' educational attainment nor for the pooled sample of schoolgirls and schoolboys. Thus, for our sample, environmental degradation and time spent collecting scarce environmental products *proxied* by the average kilograms of fuel wood and litres of water used in the households per week had no significant effect on the school attainment of the pooled sample. Attempts were made to include the corresponding hours from the field data for the respective product collecting activities in the regression. However, the results remained insignificant as it was the case with the proxies. This is not surprising, however, because from the descriptive statistics, the girls and boys spent, on average, the same number of hours per week in school activities across the environmental conditions. Though the descriptive statistics showed some minor variations of time spent on other activities like collecting scarce environmental products and/or grazing, agriculture and household chores depending on the gender biased nature of the activity and the

environment where the activity was taking place, the slight variations of time use in other activities (apart from education), affected negatively the leisure time of schoolgirls especially in the non-degraded and medium-degraded environments rather than the educational attainment of either gender.

Both the age of the schoolchild and the age-squared are statistically significant in all Columns. This implies that there was a significant non-linearity in the effect of age of the child on school attainment, decreasing after the age of 6.5 years. That is, the older the child, the more (s)he lagged behind. We obtained similar effects for the gender specific estimates. The descriptive statistics presented earlier supports this result. In our sample, we had schoolchildren in the 15 – 19 years age group who were still at primary school, suggesting that there was late entry and grade repetition, and thus not enough progress in the grade-for-age school attainment. Some schoolchildren in the 7 – 13 age cohort were not in their proper grades, indicating that they were lagging behind in educational attainment. Table 5.2 showed that only 51.2 percent of the attending schoolchildren started grade 1 at the right age of 7 as required by the educational system in Tanzania. However, the environmental degradation situations did not impact much on these delays in school attainment because the environmental products collection and/or grazing, work at home, and work on the farms, each contributed less than or equal to 5 percent only to total primary school late entry, negatively affecting the girls (see Table 5.3, Column 1).

The mother's literacy level generally had a positive and statistically significant effect on the educational attainment of the schoolchildren regardless of their gender. While the mother's secondary education significantly increased the probability of both the girls' and the boys' progress at school, the basic literacy of the mother at the primary education level significantly increased the educational attainment of the boys only. The effects were quite strong. Though the father's literacy had no effect on either boys or girls, nevertheless, the results support the findings of Al-Samarrai and Tesha (1998) that education is an investment good in the sense that the parents (in our case, mothers) invested in their children's education so that their children would have better life chances and so their offspring would be best placed to support them in later life. The schoolboys' education was favoured even by the mother with just a primary education because culturally, the boys are coheirs of the family properties. Thus, education would place them in an outstanding position to manage prudently the inheritance afterwards. Likewise, in this regard, the parents' utility would be enhanced. That is, the parents (especially the mother, in our case) considered education as an investment good. The results support the findings by Behrman and Wolfe (1987), King and Lillard (1987), and Maitra (2003) that the mother's education generally has a strong influence on the education of the children.

On the other hand, however, as would be expected, the cultural preferences in terms of the attitudes towards education had a significant negative effect on girls' educational attainment. Girls belonging to the Sambaa ethnicity compared to the other tribes living in South Pare (like the Pares and Chaggas), showed significantly lower probability of grade-to-age educational attainment. This implies that the Sambaa tribe probably did not value human capital formation of girls highly as the girls would get married and might shift to the would-be husbands' clan who, in turn, would benefit from the educational investment previously done by the girls' parents.

Table 5.3. Estimation results: Ordered Probit:Dependent variable: Primary school attainment

Variable	(1) Schoolgirl		(2) Schoolboy		(3) All (pooled)	
	Coef.	Std. err	Coeff.	Std. err	Coef	Std.err
medium-degraded dummy[c]	0.30	0.42	-0.12	0.38	-0.04	0.26
severely-degraded dummy[c]	-1.88	0.92**	0.63	0.62	-0.17	0.45
Age	1.11	0.60*	0.64	0.40	0.65	0.29**
Age squared	-0.07	0.02***	-0.05	0.02***	-0.05	0.01***
Father's ethnicity (sambaa tribe) dummy[a]	-2.38	0.72***	0.07	0.55	-0.51	0.40
Mother's ethnicity (sambaa tribe) dummy[a]	-1.52	0.52***	0.21	0.59	-0.14	0.34
Mother's primary education dummy[b]	--	--	3.11	1.00***	0.74	0.61
Mother's secondary education dummy[b]	3.15	0.72***	3.63	1.22***	1.92	0.73***
Father's primary education dummy[b]	--	--	0.57	0.60	-0.08	0.53
Father's secondary education dummy[b]	0.54	0.41	0.27	0.73	-0.22	0.59
Father's occupation (Government employee) dummy[e]	-0.98	0.83	-0.67	-1.03	-0.28	0.46
Mother's occupation (Government employee) dummy[e]	-3.39	1.58**	3.04	2.47**	0.16	0.71
Log # females	0.97	0.74	0.14	0.48	0.13	0.37
Log # males	-0.45	0.61	0.07	0.79	-0.17	0.43
Log # hours on schooling per week	-11.22	8.93	6.10	10.08	0.11	1.00
Zero hours on schooling per week	-35.19	29.20	19.11	32.89	--	--
Log # hours on domestic chores per week	0.41	0.74	0.04	0.79	0.17	0.49
Zero # hours on domestic chores per week	0.71	1.03	0.25	1.02	0.41	0.64
Log # Leisure hours per week	-0.63	0.70	0.70	0.56	0.04	0.40
Zero # Leisure hours per week	-1.01	1.50	2.23	1.24*	0.36	0.87
Log household water in litres per week	0.56	0.55	-0.18	0.67	0.40	0.38
Log household fuel wood in kilograms per week	-0.17	0.55	-0.29	0.47	-0.35	0.33
Log cropped land size	-0.41	0.52	1.06	0.56*	0.04	0.34
Grazing dummy (yes = 1)	--	--	0.33	0.60	0.77	0.35**
Log total annual household income in Tshs.[d]	0.09	0.30	-0.44	0.31	0.01	0.20
Zero annual household income in Tshs.[d]	0.09	0.71	-0.96	0.78	-0.01	0.48
Interaction term (medium-degraded*total annual income)[d]	0.51	0.41	0.78	0.40*	0.37	0.24
Interaction term (medium-degraded*zero annual income)[d]	1.24	0.97	2.01	0.98**	1.09	0.60*
Interaction term (severely-degraded*total annual income)[d]	-0.36	0.38	-0.07	0.37	-0.17	0.23
Interaction term (severely-degraded*zero annual income)[d]	-1.50	1.11	0.30	0.97	-0.24	0.64
Gender dummy[f]	--	--	--	--	0.04	0.16
Thresholds (cuts)	Coef.	Std. err	Coeff.	Std. err	Coef	Std.err
μ_1	−12.85	7.03			−3.34	3.05
μ_2	−10.72	7.11	5.68	7.41	−1.48	3.04
μ_3	−9.53	7.13	6.53	7.42	−0.68	3.04
μ_4	−7.72	7.16	8.15	7.44	0.85	3.06
μ_5	−6.13	7.19	9.02	7.46	1.90	3.07
μ_6	−4.56	7.16	10.50	7.46	3.25	3.07
μ_7	−2.21	7.12	12.20	7.45	5.01	3.05
$LR\ \chi^2$	166.42		143.81		255.17	
$Prob > \chi^2$	0.000		0.000		0.000	
$Pseudo\ R^2$	0.373		0.293		0.270	
N	149		152		301	
Post – estimation: Greene's parameterization						
Thresholds	Coef.	Std. err	Coeff.	Std. err	Coef	Std.err
μ_1	2.13	1.50	--	--	1.86	1.01
μ_2	3.32	1.47**	0.85	0.40**	2.66	1.02***
μ_3	5.13	1.52***	2.47	0.46***	4.19	1.03***
μ_4	6.71	1.56***	3.34	0.48***	5.24	1.05***
μ_5	8.29	1.58***	4.82	0.51***	6.60	1.06***
μ_6	10.64	1.63***	6.53	0.56***	8.35	1.07***
μ_7						

Legend:

- Because of the zero hours (or zero extra income) if either a schoolchild did not participate in that particular work (or if the household did not have income); then the following technique was applied:
  [a] (Dummy x log (hours), or (Dummy x log (income))
  [b] (1 – Dummy)
  Where if not observed log (hours) or log (income) = 0. Dummy = 1 if the child was participating (or if the household had income) and 0 if else.
- * $P < .1$, ** $P < .05$, *** $P < .01$
- [b] = reference education level is " illiteracy"
- [c] = reference category: Non-degraded.
- [e] = reference occupation is "other"
- [a] = reference tribe is "other".
- [f] = reference gender is the schoolboy
- [d] = income , as defined in the text, is the total household income from all sources minus the monetary value of the home consumption of the survey crops.

The other result worth noting is the mother's occupation. The formal employment status of the mother at a government office significantly decreased the probability of educational attainment for schoolgirls, whereas the probability of educational attainment for schoolboys was significantly enhanced. Taking the ceteris paribus condition, the absence of the mother at home during the day due to employment obligation, would leave the household chores unattended if the schoolgirl in the household would not replace her mother. Thus, the households would loose comparatively more hours worked on household chores if they sent girls to schools than when they sent boys. If they decided not to send the schoolgirl to school to fill in the gap of the mother's day absence at home, then, the girls would be affected much more than the boys in educational attainment.

The cropped land size, and the interaction term of the medium-degraded environment and the household annual income increased, at a 10 percent level of significance, the probability that schoolboys would progress at school. As discussed in Chapter 4, household income comes mainly from the sales of agricultural produce excluding own-household consumption. The income was used to meet the household cash demands in several respects, including the direct costs of schooling. Since there was no information on market-priced school goods reported in the data, the direct cost of schooling was implicitly reflected in the household income. An increase in the household income would, in turn, enhance indirectly the educational attainment of the child. Since the human capital formation of boys was favoured in the area, then, its effect would significantly increase the probability of school attainment for them. In Chapter 4 we showed that the agricultural produce, which was the main source of household income, was highly dependent on the cropped land size. It is no wonder then, that the cropped land size too, though at a lower degree, had a significant impact on the increase of the probability that the schoolboy would progress at school.

Lastly, Greene's parameterization (lower part of Table 5.3) shows that all point estimates, except μ_1 for both schoolgirls' and the pooled regressions, were highly significant. The results suggest that the determination of the likely school attainment classification for a particular schoolchild in our analysis suited the data, and was statistically meaningful. μ_1 was not significant for the schoolgirls and in the pooled regressions because there was just one observation in the dataset of a schoolchild who was falling behind for 6 years in educational attainment. That particular child was a girl. This explains why the thresholds for the boys' regression were only 6 because the highest delay in educational attainment was 5.

5.7. Conclusion

Our interest in this chapter was to test whether school attendance and progress of children in rural primary schools, with respect to their gender, was inversely affected by deteriorating environmental resources. Our findings show that there were other factors that significantly affected the probability of school attainment for the schoolchildren apart from the environmental degradation situations. Environmental degradation, in all estimates except for the schoolgirls in severely-degraded environment, did not have a significant impact. Reasons discussed ad hoc in Section 5.6, and now put together here, were mainly two. Firstly, girls and boys spent, on average, the same number of hours per week in school activities across environmental conditions. Secondly, the reasons mentioned indicate deteriorating resources like environmental products collection and/or grazing, work at home, and work on the farms, each contributed only marginally (less than 5 percent) to total primary school late entry. In the regression, those factors negatively affected the girls only.

Furthermore, though all three regressions in Table 5.3 had satisfactory explanatory power for educational attainment, the Pseudo-R^2 however might be improved in future research by adding school crowdedness, illness, bad weather, et cetera. These factors, together with "other" reasons suspected to include street petty trading, and poor quality of some primary schools, were equally important factors for late school entry, and consequently, for the delay in the grade-to-age school attainment (see Table 5.2). Hence we suggest that the educational attainment in South Pare was also associated with bad health (illness), school absenteeism due to petty trading and/or informal casual labour, and poor quality of some primary schools. By poor school quality we refer to the low teacher-pupils ratio (that is, shortages of teachers), teachers' incompetence, and the shortages of learning facilities such as books, school desks, proper classrooms, etc., all of which in the Tanzanian context, are funded by the local government assisted with the central government. The policy makers therefore, in their attempt to improve educational attainment and human capital formation at primary level should, as well, focus on these other relevant factors excluded from our model. For either the local or central government to be able to fund the learning facilities, the growth of the economy is an important aspect. The policy makers thus need to make overall strategies that would guarantee high growth rate of the economy in both the medium and long term, which in turn, will increase the budgetary allocations to the education sector to cater for both recurrent and capital expenditures. At the moment, the government resources committed to education are low (Mbelle and Katabaro 2003). Moreover, the non-government sector may also be enticed into investing in education through attractive fiscal incentives.

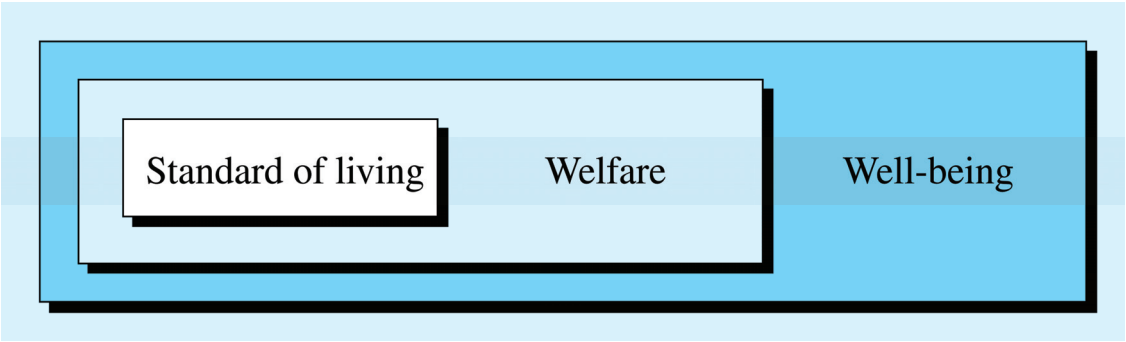
CHAPTER 6

DETERIORATING ENVIRONMENTAL RESOURCES, SUBJECTIVE ECONOMIC WELFARE AND WELL-BEING OF HOUSEHOLDS

6.1. Introduction

There is a Dutch tradition of studying subjective welfare in connection with the economic circumstances of the household, e.g., income, family composition, age and employment (Van Praag and Ferrer-i-Carbonell, 2004). Within this research tradition, measures of subjective poverty lines and income evaluation have been developed. These measures can be useful in studying the effects of environmental degradation on subjective economic welfare of households. We take the challenge to apply these measures in the rural areas of the Tanzanian South Pare highlands context. We also apply the same approach to another subjective measure, called well-being as developed by Gurin et al. (1960). Thus we obtain estimates of the effects of environmental degradation on both welfare and well-being.

The two concepts, namely *welfare* and *well-being,* need to be considered in detail. The first stands for the narrow concept of satisfaction derived from income or *monetary* welfare. The second concept is a much wider concept; it stands for satisfaction with life as a whole. Figure 6.1 illustrates how these two concepts fit together. Figure 6.1 also introduces a third concept, *standard of living. The standard of living* refers to material issues only (*material welfare)*, such as income, wealth and goods (Antonides and Raaij, 1998) (see Chapter 2). In this chapter, we mostly consider *welfare* and *well-being* concepts.



Source: Antonides and Raaij (1998).

Figure 6.1. Standard of living, welfare and well-being

The rest of the chapter is organized as follows:
First, in Section 6.2 we present a literature review of the studies on the determinants of subjective welfare and well-being that we employ in our study. This is followed by the methodology in Section 6.3, which is to be applied in the data analysis. Section 6.4 describes the data used. The empirical analysis and discussion are offered in Section 6.5. Section 6.6 concludes the chapter.

6.2. Determinants of subjective welfare and well-being: A review

This section presents a selection of empirical findings in the literature that used direct questions of welfare and well-being. The objective of this section is twofold. First, the results obtained in several studies allow us to select the determinants of welfare and well-being that we may apply in our analysis. This in turn offers a view on the structure of individual welfare and well-being of the people in the Tanzanian South Pare highlands. Second, the empirical findings in the literature of subjective welfare and well-being are used to examine the consistency, across time and countries, of the answers to subjective questions. Consistency among studies would provide support for the significance and reliability of the method that uses direct questions to measure individual welfare and well-being. In other words, consistency would represent an *empirical validation* of the meaningfulness of the answers to our survey questions.

The literature on the determinants of subjective well-being, *hereafter abbreviated 'SWB,'* draws special attention to income and employment variables. In addition, variables such as health, children and environmental factors are discussed. The determinants of SWB are divided in two groups, namely, objective variables (e.g., income and age) and subjective variables (e.g., financial satisfaction). The objective variables are called *external factors* of SWB, while the subjective variables are related to *internal factors* (Diener and Lucas, 1999). Objective variables do not fully explain individual SWB, especially since the importance of personality on determining individual well-being and happiness cannot be neglected. Objective socio-economic and demographic variables explain somewhere between 8 and 20 percent of an individual's subjective well-being (see Kahneman et al., 1999). This finding has led to a shift in the psychological literature from studying external factors to focusing on internal factors. For economists, however, external factors, such as income or employment, are still very important. In other words, not only are the SWB levels and changes relevant but also the 'resources' and the 'objective environment' that partly determine SWB.

6.2.1. Subjective well-being and income

The relationship between income and SWB has been one of the most discussed topics in the SWB literature. The main and most controversial issue has been the role of income in individual well-being. Many early studies on SWB claimed that income was correlated weakly with SWB. Furthermore, it was argued that in poor countries, or among poor people in richer countries, the correlation between income and life satisfaction was higher than for richer countries or people. This suggests that increases of income considerably enhance well-being until a certain threshold level, after which further increases of income do not improve individual well-being substantially. More research based on larger data sets supports this conclusion (Argyle, 1999; Diener et al., 1993).

Nevertheless, these results should not be interpreted to mean that income is totally irrelevant for well-being beyond certain income levels. Income allows people, in modern societies, to enjoy, for example, expensive leisure activities and holidays at long distances away from home. This statement could be interpreted as contradicting the aforementioned empirical findings. However, the following points should be kept in mind,

First, more important than income in absolute terms ('absolute income') is the perception of income ('subjective income'). In other words, general satisfaction with life

(SWB) depends on whether individuals perceive their income as adequate to satisfy their needs, where needs include not only food and shelter but also higher needs such as social acceptance or self-esteem (see Maslow, 1970). This argument is empirically sustained by the higher correlation found between SWB and 'subjective income' than between SWB and 'absolute income.' For example, Schyns (2000) found for the Russian Federation that 'income satisfaction' was more highly correlated with SWB than 'absolute income.' Similarly, financial satisfaction usually has the highest coefficient when regressing SWB on various domain-specific satisfaction measures (Van Praag, Frijters and Ferrer-i-Carbonell, 2000). This indicates that satisfaction with one's own financial situation is an essential part of SWB.

Second, one's own income compared with (or relative to) the income of other people has an influence on SWB. This reflects the fact that satisfaction with one's own income depends on the relative position of the individual in society. According to Easterlin (1995, p.36): "... happiness or subjective well-being, varies directly with one's own income and inversely with the incomes of others." The idea that individuals compare their income with that of other people is clearly consistent with the social comparison models and discrepancy theories in psychology (see, e.g., Michalos, 1985). In Russia, for example, a variable defined as 'my financial situation is much less than average,…, much more than average' showed a much higher correlation with SWB than the family income itself. An important question in this context is: What is the reference group of an individual (Van der Sar et al., 1988)? Does it include people from the same neighbourhood or with the same level of education? There has been some theoretical and empirical work on the importance of reference groups for individual welfare and well-being (see, e.g., Falk and Knell, 2000; Van de Stadt et al., 1985; Woittiez and Kapteyn, 1998).

Third, individual income perception depends on one's own situation in the past. Easterlin (1995) calls this 'habit formation': changes in income are more important determinants of individuals' satisfaction with life than 'absolute income.' Nevertheless, individuals seem to adapt to income increases by changing their expectations. This suggests that income increases will increase satisfaction only temporarily. An example supporting this view is a study of lottery winners reporting higher levels of satisfaction only for a short time after winning a lottery (Brickman et al., 1978). Similarly, Schyns (1999, 2000) found a small coefficient for the effect of changes in income on life satisfaction in Germany and the Russian Federation. In an extensive literature review, Diener and Biswas-Diener (1999) conclude that changes in income do not influence SWB, contrary to expectations, while average income does. A relevant question for economists is whether the adaptation phenomenon only relates to an income increase or also to an income reduction. Frey and Stutzer (1999) found for Switzerland that income increases with respect to the previous year had a very small effect on general satisfaction with life (SWB), while income reductions had a significantly negative impact on SWB. Adaptation theory, therefore, needs to be treated with some caution as the evidence is contradictory (see also Frederick and Loewenstein, 1999; Diener et al., 1997). The income adaptation evidence led Easterlin (2000) to draw a distinction between long-term and short-term utility. According to Easterlin, as income increases, aspirations change. In particular, income increases shift the short-term utility curve to the right, giving rise to an almost 'flat' long term-utility. Earlier, Van Praag (1971) had already found this result, which he refers to as *preference drift*.

6.2.2. Subjective well-being and employment

Having a job is positively correlated with subjective well-being, and being unemployed negatively (Clark and Oswald, 1994; Frey and Stutzer, 1999; Oswald, 1997; Winkelmann and Winkelmann, 1998; Woittiez and Theeuwes, 1998). Clark and Oswald (1994) found 'unemployment' to be the most relevant variable for mental distress, with higher coefficients than variables such as being divorced or being a widower. This is consistent with suicide statistics, which indicate that being unemployed is the main cause of emotional distress (Oswald, 1997). Similarly, other studies have detected a high correlation between subjectively evaluated job satisfaction (a domain satisfaction) and SWB (see Tait et al., 1989). Clearly, being satisfied with one's job is not the same as being unemployed. Unemployment has two impacts: first, it adversely affects the financial stability of the individual, and secondly, it is a source of emotional instability and reduction of self-esteem. Several studies have found that the 'non-pecuniary' costs of being unemployed are more important than the economic costs (see Oswald, 1997, for the UK; Winkelmann and Winkelmann, 1998, for Germany; and Frey and Stutzer, 1999, for Switzerland). This result suggests that economic policies aimed at reducing unemployment are more relevant for increasing SWB than welfare policies that focus on compensating unemployed individuals for a loss of income. Clark and Oswald (1994) and Clark (2000), however, find that the negative effects of being unemployed vary across groups, being the least negative for young people, individuals living in areas with a high unemployment rate, and people who have been unemployed for a long time.

6.2.3. Subjective well-being and other economic, social, and demographic variables

Several other variables relevant for SWB have been discussed. While in early studies it was argued that increases in age reduced happiness, recent findings suggest that this is not a universal truth. Many studies find a negative correlation between age and SWB only until mid-life (the 30s and 40s), after which satisfaction increases with age. This is the well-known 'age *U*-shaped relationship' (see Clark and Oswald, 1994; Oswald, 1997; Van Praag et al., 2000). Much of the evidence is based on either cross-sectional analysis or longitudinal studies. Since these do not correct for a generation effect, age and cohort effects cannot be separated.

Gender differences are usually very small. Women are, in general, more frequently depressed and experience more negative emotions than men but are not consistently unhappier. Diener et al. (1999) explain this by suggesting that even if women experience negative emotions more often, they also experience more positive emotions, so that these balance out. The empirical evidence using SWB questions seems contradictory. Some studies find women to be happier and others men, but the difference tends to be small. Van Praag et al. (2000) find that Germany women are in general more satisfied except with regard to leisure. Having a partner or being married contributes positively to life satisfaction (Argyle, 1999; Lee et al., 1991, Oswald, 1997). Love, partnership, and marriage have been found to be positively and highly correlated with subjective well-being, as well as with one's health (Myres, 1999). It is not clear, however, which influence dominates: whether having a partner increases individual well-being, or whether being happy increases the probability of getting and maintaining a partner (Diener et al., 1997). Surprisingly perhaps, the number of children has, in general, a small negative impact on life satisfaction

(Argyle, 1999; Clark and Oswald, 1994; Frey and Stutzer, 1999; Van Praag et al., 2000). Health correlates highly with SWB (see, e.g., Ferrer-i-Carbonell and Van Praag, 2000). This correlation is generally lower when health is measured by objective variables than by subjective or self-reported variables (Argyle, 1999). This reflects the importance of personality, which influences the subjective evaluation of one's own health situation (Diener and Lucas, 1999; Diener et al., 1999).

Some other individual characteristics correlate with SWB. Religion correlates positively with SWB (see Ellison, 1991). Education is normally also found to have a positive though low correlation with SWB. It is, however, difficult to disentangle whether the correlation is due to a pure education effect or due to other factors that are correlated with higher education, such as having a higher 'social status' and having an 'exciting job' (Diener et al., 1999). The relationship between inflation and SWB is also found to be negative (see, e.g., Di Tella et al., 1999). Finally, direct democracy, i.e., the possibility to participate in a referendum, is found to correlate positively with SWB in a study for Switzerland (Frey and Stutzer, 2000a).

The empirical findings based on subjective questions of welfare and well-being, are all from developed countries, locally termed in Tanzania as "western" literature. So far, no literature exists, at least in the study area, which looks at the household subjective welfare and well-being in the current approach. More so, no literature exists in South Pare that examines the effects of environmental degradation on subjective welfare and well-being. It is because of this non-existence of local literature that makes us use, with adaptations, the "western" structure of individual well-being and welfare so as to maintain consistency across time and countries. The phrase "with adaptations" suggests that while the structure and methodology of analysis remain the same, determinants of subjective welfare and SWB may either be added, or deducted, or redefined to fit the local context. 'Determinants' in question subject to re-definition are (1) employment, and (2) household income. 'Determinants' subject to addition are ethnicity, the quantity/volume of scarce environmental products used in the households and their corresponding duration in hours spent on fetching fuel wood or grazing cattle. 'Determinants' subject to deduction mainly due to lack of data are mainly social and demographic variables, including health, religion, love, partnership, and marriage. The 'added' determinants will be explained in the methodology section (6.3) together with the explanation of the corresponding equations to be estimated. The 're-defined' determinants, that is, employment and income, are external factors which, for economists, are very important and need to be focused from the start.

6.2.4. Redefined variables

6.2.4.1. Employment

We learn, from Chapter 4 (this thesis), that though labour market opportunities exist in South Pare for both husbands and wives, statistics tell us that only 7.0 percent of the husbands from the sample households and 2.6 percent of the wives have formal employment either in the government sector, or in the private sector, or are self-employed in petty business. This means that most people in South Pare are self-employed (informally employed) in non-mechanized agriculture. In this understanding, we redefine "employment" as "occupation." Occupation is further split into several 'work' variables. The 'work' variables of importance in our study are informal employment, namely being a

farmer, or formal employment, that is working in an office as an employee. In our analysis, occupation is a dummy variable. Formal employment, though it comprises a small section of the sample, is nevertheless included to examine its influence on SWB because from the previous chapters (especially Chapter 5), the variable had a significant impact on educational attainment of the schoolchildren. It might have an influence in this regard, too.

6.2.4.2. Income

In the 'western' literature reviewed above, income refers to 'earned' income from wage employment. With our redefinition of employment into occupation, total household income then refers, as earlier defined in Chapter 4 (Sections 4.2 and 4.4), to the sum of net earnings from selling agricultural produce (informal employment) and labour (formal employment). Household income also includes exogenous income a household receives in kind from grants, presents and remittances. Income from formal employment comprises salaries, fringe-benefits, and/or pension once the employee retires. We, however, subtract the monetary value of domestic consumption from own produce so as to avoid the problem of double counting where own consumption is considered as a separate variable.

6.3. Methodology

The concepts of *welfare* and *well-being* each are measured by a separate measurement instrument.

6.3.1. The individual welfare function of income

One of the *welfare* measurement instruments is the individual welfare function of income, *abbreviated WFI,* introduced by Van Praag (1968, 1971). The *WFI* is an operationalized version of the cardinal utility function of income. It describes how an individual evaluates different income levels, and it is estimated by posing the *Income-Evaluation Question (IEQ)* (Van Praag, 1971; Goedhart et al., 1977). The *IEQ* is a question module in which the respondent is asked to qualify several household income levels. Mostly six levels have been used and sometimes even nine or eight, assumed to be equally spaced on the [0, 1] utility interval. In the South Pare survey it was decided, after the pilot survey, to use only three levels. The reason behind the decision was the inability of the respondents to distinguish between *very bad* and *very insufficient*, *bad* and *insufficient*, *good* and *sufficient*. In their understanding, the terms were similar in meaning, for instance, what was *very bad* was also *very insufficient;* what was *bad* was also *insufficient,* etc. Elaborating the terms could consume a lot of time as the research instrument was translated into *Kiswahili*, a local language, in which basically the terms, especially for the subsistence audience, proved to be a tautology.

The IEQ asked in the survey was:

"Which monthly household after-tax income would you consider to be very insufficient? insufficient? sufficient?"

		FATHER	***MOTHER***
VERY INSUFFICIENT	if it were about Tshs	……..	…….....
INSUFFICIENT	if it were about Tshs	……..	……
SUFFICIENT	if it were about Tshs	……..	……...

The IEQ was asked to parents only, excluding schoolchildren, for the obvious reason that schoolchildren were still dependent. However, the well-being question, to be considered later, was asked to all. The three IEQ answers of individual i are denoted by q_{ij}. The empirical individual welfare function is of the following form:

$$U(I) = \Lambda(I;\mu_i,\sigma_i) = N(\ln I;\mu_i,\sigma_i) \qquad (i = 1,..,N) \qquad (1)$$

where Λ and N indicate the log-normal and normal distribution functions, respectively. The individual welfare function varies with μ_i and σ_i, and can be estimated as follows (Van Praag, 1991):

$$\mu_i = \frac{1}{J}\sum_{j=1}^{J}\ln(q_{ij}) \qquad (i = 1,..,N;\ j = 1,2,3) \qquad (2)$$

$$\sigma_i = \sqrt{\frac{1}{(J-1)}\sum_{j=1}^{J}(\ln q_{ij} - \mu_i)^2} \qquad (3)$$

where μ is the want parameter of the welfare function and denotes the log-income that is evaluated at 0.5 on the [0,1] welfare scale. μ determines the position of utility with respect to the income $U(I)$. If μ increases, the individual becomes less satisfied with the same amount of income. That is, $U(I;\mu)$ is decreasing in μ. σ is the sensitivity parameter of the welfare function which defines the slope of the welfare function (Van Praag, 1968, p. 38). If $\sigma = 0$, it is a limiting case where individuals are completely unsatisfied with any income until their income reaches e^{μ}, and where they are completely satisfied if income exceeds e^{μ}. In the literature[36], σ cannot be explained very well by objectively measurable socio-economic traits and is, in most cases, assumed to be just a scalar. Although we will also, in this chapter, concentrate on the explanation of μ, an attempt to report σ and explain its values will be made. q_{ij} stands for the three income levels (q_1, q_2, q_3) reported in the IEQ by respondent i.

To enable us to use the IEQ for welfare comparisons, we make the assumption that all households in the language community attach the same verbal label to the same welfare level. This assumption of the same feeling to every respondent is crucial because,

[36] Van Praag (1977), Van Praag and Frijters (1998).

otherwise, we would falsely assume that individuals derive the same degree of joy from their income, when describing the same verbal label.

In the literature[37], the individual parameter μ varies with household income I and household size H, measured by the number of family members. Thus, the individual value of μ is explained by equation (4):

$$\mu = \beta_0 + \beta_1 \ln(H) + \beta_2 \ln(I) + \varepsilon \qquad (4)$$

Since e^{μ} equals the income associated with an evaluation of 0.5, equation (4) implies that wants increase with increasing household size and increasing income (when the coefficients β_1 and β_2 are positive). ε is a random disturbance term with zero expectation, distributed identically for each individual in the household.

In the present study, in the regression part, we extend the explanation of the welfare parameters by taking into account other personal variables including educational level S, and occupation J. Furthermore, we also include environmental degradation E, and the average quantity/volume in kilograms/litres of the environmental products P_m consumed in the household per month. Environmental degradation (E) is added to the equation because, together with the environmental products variables, they reflect resource scarcity. Assuming the ceteris paribus condition, poor environmental quality implies less availability of environmental products leading to higher opportunity costs. Consequently, the want welfare parameter will increase with deteriorating environmental circumstances, suggesting that the individual will need higher income to maintain the same welfare level. The inverse may also be true. That is, better environmental quality implies abundant environmental products, lower opportunity costs, and a lower want parameter leading to lower income required to remain at the same welfare level as before. However, from the knowledge obtained in the preceding discussions, we expect complications in the results and analysis because the availability of some environmental products, say, fuel wood in the non-degraded area, is constrained not only by the quality of the environment but also by the current by-laws prevailing in the area (prohibiting logging in the non-degraded area).

In the regression, environmental degradation is specified by means of dummy variables, with non-degraded environment being taken as the reference category. The environmental products, as defined earlier in the preceding chapters, refer to meal-related environmental products of fuel wood, denoted by P_m^f, and water, abbreviated as P_m^w, all measured in logarithms. We propose the following relationship for estimation:

$$\mu = \beta_0 + \beta_1 \ln(H) + \beta_2 \ln(I) + \beta_3 P_m^f + \beta_4 P_m^w + \beta_5 \ln(co) + \beta_6 J + \beta_7 S + \beta_8 E + \varepsilon \qquad (5)$$

The welfare parameter μ depends on, *inter alia,* the current income of the individual. Thus, individuals with different current incomes are expected to evaluate a specific income level differently. This phenomenon, embodied in β_1, as it was already explained in Section 6.2.1 of the literature review, is called *preference drift* (see Van Praag, 1971). That is, before it happens, an income increase will be valued highly, but after it has

[37] Van Praag (1971), Van Praag and Kapteyn (1973), Hagenaars (1986), Van Praag and Flik (1992).

occurred, one becomes used to it and one's evaluation of the increased income becomes lower. Preference drift is also called *hedonic treadmill* in a more generalized context (Brickman and Campbell, 1971). It is an empirical operationalization of the notion that welfare functions are evaluated relative to current circumstances within and outside of households (Van der Stadt et al., 1985).

By looking at the amount of money individuals in households need to reach a given level of welfare, we are measuring the costs induced by environmental degradation conditions. In this regard, bias might arise if respondents did not answer the IEQ correctly, that is, if they had no firm idea as to what income they would need to realize a welfare level different from the present. However, the bias was minimized in two ways: Firstly, we did not ask the respondent to be explicitly aware of the effects of environmental degradation on welfare, nor that he attempted to give a money translation of environmental degradation changes. We only asked if he/she knew how much money he/she needed to reach a certain welfare level in his/her present circumstances. Secondly, we took direct account of the fact that welfare depends on the reference position via the preference drift phenomenon.

6.3.2. Subjective well-being

Well-being is a much broader concept than financial satisfaction or welfare. Its measurement is a satisfaction-with-life question developed by Gurin et al. (1960). Antonides (1996) called it a *one-item scale* measure of well-being whereby there are three response choices: "Very happy," "Pretty happy" and "Not too happy."[38] This time, the Gurin-question was also asked to the schoolchildren alongside their parents but at a different time, independently, in the physical absence of their parents, and at their own conviction (so as to avoid bias in replies).

The Gurin-question asked in the survey was:

"Taking everything into account, how satisfied are you in this household with the way the household lives these days? Choose one response."

		FATHER	MOTHER	SCHOOL CHILD
Very dissatisfied	1			
Dissatisfied	2			
Satisfied	3			

The answers obtained, denoted by v_i, are numbers on a (1,3) scale, where 1 stands for very dissatisfied, 2 stands for dissatisfied and 3 stands for satisfied. The answer to this question is taken as a proxy of an individual's subjective well-being, *abbreviated SWB* (see Frey and Stutzer, 2002b; Luttmer, 2005). Individual answers are then explained according to the following model:

$$SWB_i^* = \alpha + \beta X_{ki} + \gamma E + \varepsilon \qquad (6a)$$

$$SWB_i = v \leftrightarrow \pi_v \leq SWB_i^* < \pi_{v+1}$$

[38] Gurin, et al. (1960) quoted in Antonides (1996)

where SWB is the answer to the satisfaction question, SWB^* is an unobserved latent variable, i represents the individual, v are the three discrete categories (1 to 3), π_v are two estimated intercept terms also known as "threshold parameters", X_k is a set of k explanatory variables, E denotes environmental degradation, and ε represents the usual error term. The set of k explanatory variables is the same as presented in equation (5), for welfare. However, as we do not have clear expectations on the family size effect, and there may be an optimal number of children, we introduce a squared term in $\ln(H)$. We also add an interaction term between $\ln(I)$ and $\ln(H)$, since we assume that the optimal number of children may vary with the financial situation of the household. Furthermore, we assume that well-being is age-dependent. We therefore add age and age-squared, as it is used in much of the literature (Mincer, 1963). Time spent on leisure, *abbreviated by* T_l, time spent on agriculture, *abbreviated by* T_a, and time spent on scarce environmental products collection and/or grazing, *abbreviated by* T_{mr_γ} *for meal-related environmental products (where* $\gamma = fuelwood, water$*)*, T_{ar} *for time spent on grazing, and* T_d *on domestic chores,* may also influence subjective well-being, and are added to the well-being equation. We also include household domestic consumption of the survey crops per month evaluated at monetary terms, *abbreviated by* con. The following equation, which is an elaborated version of equation (6a), to explain the Gurin measure of well-being, is proposed for empirical estimation purpose:

$$\begin{aligned} SWB_i^* &= \beta_0 + \beta_1 \ln(H) + \beta_2 (\ln H)^2 + \beta_3 \ln(I) + \beta_4 \ln(I) * \ln(H) + \beta_5 P_m^f \\ &+ \beta_6 P_m^w + \beta_7 \ln(T_{f_i}) + \beta_8 \ln(T_{w_i}) + \beta_9 \ln(T_a) + \beta_{10} \ln(T_{ar_i}) + \beta_{11} \ln(T_{d_i}) \\ &+ \beta_{12} \ln(T_{l_i}) + \beta_{13} \ln(con) + \beta_{14} J + \beta_{15} S + \beta_{16} E + \varepsilon \end{aligned} \qquad (6b)$$

where $\beta_7 \ln(T_{f_i}) + \beta_8 \ln(T_{w_i})$ is the symbolical extension of T_{mr_γ} for estimation purpose.

In this chapter, equation (6b) is estimated by means of an ordered probit. This means that SWB is assumed to be a categorical variable and thus we cannot observe the exact level of satisfaction but only the range in which it lies. Second, it is assumed that the answer to the subjective well-being question provides an ordinal (and not cardinal) ranking. Third, ordinal interpersonal comparability is assumed. This means, for example, that an individual answering "3" is more satisfied or happier than one answering "1", but not necessarily three times as happy or satisfied (Ferrer-i-Carbonell and Frijters, 2004).

The ordered probit model with three alternatives is then defined as follows:

$$SWB_i = \begin{cases} 1 \quad if \quad SWB_i^* < \pi_v \\ 2 \quad if \quad \pi_v \le SWB_i^* < \pi_{v+1} \\ 3 \quad if \quad \pi_{v+1} \le SWB_i^* \end{cases}$$

Where $\pi_v < \pi_{v+1}$. The model is estimated using maximum likelihood estimation for husbands, wives, and schoolchildren, separately.

6.4. Descriptive results

Tables 6.1a, b, c and Figure 6.2 show the frequencies of the life-satisfaction (Gurin) answers. It was observed that most parents (male and female) evaluated their lives as dissatisfactory in all environmental conditions. Most schoolchildren, on the other hand, evaluated their lives as satisfactory in all environmental conditions. The numbers in the tables suggest that most adults had low well-being, a result which is not surprising given the subsistence level of the economy they were living in. The schoolchildren were probably optimistic when they evaluated their current lives as satisfactory, however, the number of schoolchildren who were not satisfied with their current lives was also high and cannot be ignored (34.2 percent in the severely-degraded environment, 41.8 percent in the medium-degraded area, and 42.2 percent in the non-degraded place). The frequencies of very dissatisfied people were relatively high in the severely-degraded environment (20, 15 and 5 percent, for wife, husband and child, respectively) followed by people residing in the medium-degraded environment (13.2, 13.2 and 3.3 percent, respectively), and were relatively low in the non-degraded environment (8.9, 6.7 and 0 percent, respectively). The reason behind this could be the severity of life difficulties which, in general, were perceived to be stronger in the degraded area than in the non-degraded place.

Adult people (male and female) had high frequencies of life satisfaction in the medium-degraded environment (29.7 for wives, and 33.0 percent for husbands, respectively) probably because the area recorded relatively high harvest of the survey crops that year (2006/7), thus relieving the burden of buying food from the market. They had an advantage also of balancing their consumption needs to have some little amounts of extra crops for selling to meet other household cash demands (see Chapter 4, this thesis).

Table 6.1. Sample distribution across life-satisfaction categories by environmental degradation.

(a)

	Non-degraded (the upland plateau zone)			
	No. of responses	**Percentage**		
		Very dissatisfied	Dissatisfied	Satisfied
Wife	90	8.9	76.7	14.4
Husband	90	6.7	84.4	08.9
Schoolchild	90	0.0	42.2	57.8

(b)

	Medium-degraded (the middle plateau zone)			
	No. of responses	**Percentage**		
		Very dissatisfied	Dissatisfied	Satisfied
Wife	91	13.2	57.1	29.7
Husband	91	13.2	53.8	33.0
Schoolchild	91	03.3	41.8	54.9

(c)

	severely-degraded (the lowland plateau zone)			
	No. of responses	**Percentage**		
		Very dissatisfied	Dissatisfied	Satisfied
Wife	120	20.0	69.2	10.8
Husband	120	15.0	71.7	13.3
Schoolchild	120	05.0	34.2	60.8

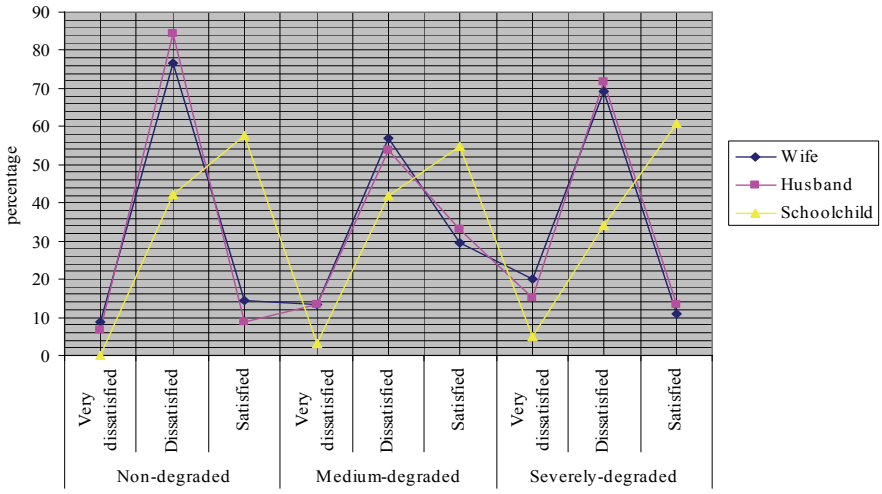


Figure 6.2. Sample distribution of life-satisfaction categories by environmental degradation.

Although most schoolchildren evaluated their lives as satisfactory in all environmental conditions, the frequency was higher in the severely-degraded area (60.8 percent) than in the medium-degraded environment (54.9 percent), and in the non-degraded area (57.8 percent). The reason could be how they spent their leisure time, and the availability of sports facilities including play grounds. The topography of the lowland favoured the children in the severely-degraded areas to have more playgrounds for sports than their counterparts on the hills. Playgrounds are a precious commodity for the children and are well-being enhancing (Lloyd and Auld, 2001; Lu and Hu, 2005). Very unfortunately, sport facilities as a variable is missing in our data set.

We also ran some correlation analyses in order to test basic associations between happiness and environmental degradation among the household members. A simple correlation analysis showed a correlation of -0.175 between happiness and environmental degradation ($p<.001$) for wives and a correlation of -0.115 ($p<.001$) for husbands. As we could suspect from the above, the correlation between happiness and environmental degradation for schoolchildren was not significant, suggesting that the quality of the environment might not have a direct relation to the happiness of the children. Bradshaw et al., (2007a,b) suggested seven direct domains of child well-being, namely; material well-being, housing, health, risk and safety, education, personal and social well-being and family care. However, their analysis was for the European countries which might not necessarily fit the South Pare case which is situated in a developing country. Although still unexplored, taking the communal sense of life in the African setting, we could propose factors like family care, parental love, and social interactions including entertainments such as sports in open playgrounds being fundamental in directly enhancing the children's happiness regardless of the state of environmental degradation.

With regard to subjective economic welfare, Tables 6.2a,b,c present average reported income levels given in response to the IEQ by environmental degradation. 602 adults responded to the income evaluation question (IEQ), including 301 husbands and 301 wives.

Both parents in all environmental conditions on average rated an income of 53,000 Tanzanian Shillings per month as very insufficient income. An income of 53,000 Tanzanian Shillings was equivalent to 44.17 US Dollars per month at the exchange rate of 1,200 Tanzanian Shillings per 1 US Dollar in 2006/7. The income of 53,000 Tanzanian Shillings per month was less than the official Government minimum wage in 2006/7 which was 75,340 Tanzanian Shillings, equivalent to 62.78 US Dollars per month. With the exception of wives in the severely-degraded environment who rated an income of 74,000 Tanzanian Shillings per month to be insufficient, which is marginally below the minimum wage, all other adults across environmental degradation situations rated an income between 80,000 and 106,000 Tanzanian Shillings as insufficient. The average reported income suggests that the official minimum wage was not only 'very insufficient' but was also 'insufficient' to most adults across the environmental degradation situations. The highest monthly income reported by the wife and the husband to be sufficient was 268,000 Tanzanian Shillings and 260,000 Tanzanian Shillings respectively, all recorded in the non-degraded environment. Likewise, the minimum monthly income deemed sufficient by the wife and the husband was 166,000 Tanzanian Shillings and 189,000 Tanzanian Shillings respectively, all reported in the medium-degraded environment. As stated earlier, this is not surprising because respondents in the non-degraded area needed higher income, inter alia, to purchase staple food crops which were not performing well at the high altitudes, while the households in the medium-degraded area harvested enough food in the 2005/6 agricultural season for their own household consumption and marketed the remaining portion for cash. Subsistence consumption is a substantial part of household consumption in the medium-degraded environment in South Pare. At the national level, it was estimated that about 30 to 60 percent of farm production in rural areas of Tanzania where food crops were grown was consumed at the farm; the remaining part was marketed (Moshi et al., 1997; Nkonya and Parcel 1999).

In our research, to avoid bias, we did neither ask respondents whether they were explicitly aware of the effects of environmental degradation on welfare, nor did we attempt to ask them to give a monetary translation of environmental degradation. We only asked how much money they rated to be 'very insufficient', 'insufficient' and 'sufficient'. We therefore ran correlation analyses to check for associations between subjective economic welfare and environmental degradation for husband and wife separately. The correlation between the income needed at particular welfare levels and environmental degradation was highly significant at $P < .01$ with correlation coefficients ranging from -0.189 to -0.229 for 'sufficient' income and significant either at $P < .05$ or $P < .01$ with correlation coefficients between -0.183 to -0.203 for 'very insufficient' and 'insufficient' incomes for husband and wife separately, suggesting a negative influence of environmental degradation on income needed to attain a particular level of welfare.

Table 6.2. Self-rated average income levels by environmental degradation and by utility level.

(a)

	Non-degraded (the upland plateau zone)		
	Tanzanian Shillings (x 1000)		
	Very insufficient income	Insufficient income	Sufficient income
Wife	52	90	268
Husband	53	88	260

(b)

	Medium-degraded (the middle plateau zone)		
	Tanzanian Shillings (x 1000)		
	Very insufficient income	Insufficient income	Sufficient income
Wife	45	89	166
Husband	53	106	189

(c)

	Severely-degraded (the lowland plateau zone)		
	Tanzanian Shillings (x 1000)		
	Very insufficient income	Insufficient income	Sufficient income
Wife	40	74	230
Husband	44	80	254

Note: *The exchange rate in 2006/7 was 1,200 Tshs = 1 US$.*

The dataset also included a large number of socio-economic and demographic variables referring to the individual and household situation, such as occupation, literacy level, household size, household income and environmental degradation. As shown in the literature review, these variables were useful in explaining welfare and well-being and are therefore included in the analysis.

6.5. Estimation results and discussion

6.5.1. Subjective economic welfare

The first objective of this chapter was to study the individual welfare function in South Pare. Our interest in this respect was in the survey answers from the "income evaluation question" (IEQ). According to the method described in Section 6.3.1, and corresponding equations (1), (2) and (3), we estimated μ and σ of 301 husbands and 301 wives separately. Moreover, we estimated for each individual the own income evaluation by filling in the reported income into his/her own welfare function. From equation (1), let the *i*th individual have a welfare function $\Lambda(I;\mu_i,\sigma_i)$, then we estimated μ , σ and $\Lambda(I.;\mu_i,\sigma_i)$ with μ and σ as they were previously defined in equations (2) and (3), and I the household income.

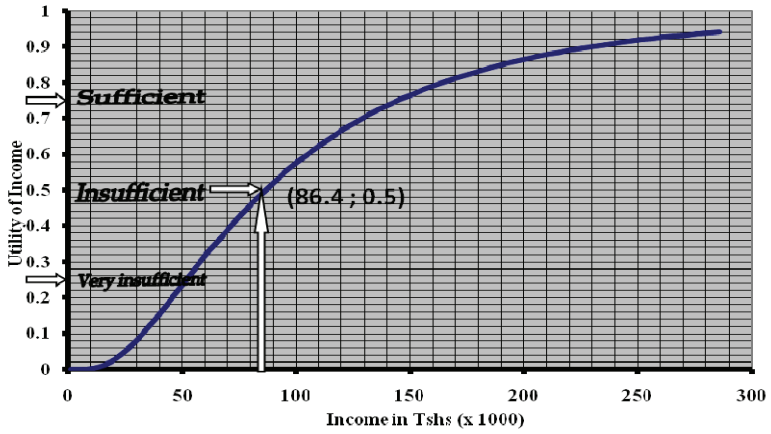
Table 6.3 shows the average estimated values of the individual welfare function of income. First, we see that the values of μ , denoting the log-income evaluated at 0.5 on the [0,1] welfare scale, averaged 4.46 for husbands and 4.39 for wives. The income numerals in the dataset were in thousands Tshs, therefore, $[(e^{\mu})x(1000)]$ equals the average income in Tshs evaluated by an individual as insufficient. On the other hand, the values of sensitivity parameter σ of the welfare function were 0.76 for husbands and 0.77 for wives, suggesting that husbands and wives had equally steep welfare functions. After calculation, $[(e^{\mu})x(1000)]$ gives 86,487 Tanzanian Shillings for husbands and 80,640 Tanzanian

Shillings for wives, respectively. Meanwhile, as stated in the data section (6.4), the official Government minimum wage in 2006/7 was 75,340 Tanzanian Shillings per month. This means that individuals in South Pare would need an income well above the official minimum wage per month to experience even an insufficient income. The values of utility of income $U(I)$ averaged 0.05 for husbands and 0.06 for wives.

The average R^2 of the individual welfare regressions equalled 0.96, which is quite high, given the small number of welfare levels used. The average welfare function for husbands $\Lambda(I;4.46,0.76)$ is sketched in Figure 6.3.

Table 6.3. The individual welfare function of income.

	N	μ	σ	$U(I)$	R^2
Husband	301	4.46	0.76	0.05	0.96
Wife	301	4.39	0.77	0.06	0.96



$(\mu = 4.46; \quad \sigma = 0.76)$

Figure 6.3. The welfare function of income in South Pare (average husband)

The functional specification of equation (4) proved to be successful in the literature[39] and we wanted to know whether the same could apply to South Pare. Equation (4) considers only two determinants of the individual want parameter μ , namely household income I and household size H . From the theory in Section 6.3.1., we expected wants to increase with increasing household size and increasing income, resulting in positive coefficients of these two determinants.

Tables 6.4a,b show the estimation results for equation (4). Starting with Table 6.4a, as we expected, the coefficients of household income and household size were positive and highly significant ($P < .01$) suggesting that they significantly increased the individual welfare parameters of both wife and husband. The difference in the results between husband and wife was negligible, meaning that we can give one interpretation referring to any of the two without creating a technical distortion.

[39] Van Praag (1971), Van Praag and Kapteyn (1973), Hagenaars (1986), Van Praag and Flik (1992).

Table 6.4a. Welfare function with two determinants. Dependent variable is μ

Variable	(1) Husband		(2) Wife	
	Coef.	Std. err	Coeff.	Std. err
Ln total monthly household income in Tshs	0.07	(0.02)***	0.05	(0.02)**
Ln household size	0.29	(0.11)***	0.28	*
Constant	3.85	(0.20)***	3.81	(0.10)**
				*
				(0.19)**
				*
Adjusted R^2	0.05		0.04	
N	301		301	

Legend:

- $*P<.1$, $**P<.05$, $***P<.01$
- Standard errors in brackets

Table 6.4b. Welfare function with two determinants. Dependent variable is σ

Variable	(1) Husband		(2) Wife	
	Coef.	Std. err	Coeff.	Std. err
Ln total monthly household income in Tshs	0.01	(0.12)	0.15	(0.13)
Ln household size	-0.06	(0.67)	-0.04	(0.07)
Constant	0.84	(0.12)	0.82	(0.13)
Adjusted R^2	-0.01		0.00	
N	301		301	

Legend:

- $*P<.1$, $**P<.05$, $***P<.01$
- Standard errors in brackets

The values of the preference drift β_2 and the household size elasticity β_1 were almost the same for husband and for wife. This is not surprising because they had experienced the same external conditions (like economic life) within the same household.

The values of the household size elasticity were small (0.29 and 0.28). Theoretically, the value of the household size elasticity is an indication of the change in welfare caused by a change in household size, at the margin. If we had a family where each child had to have his/her own room, study at the university, etc., then we would expect to have a high β_1. However, the reality in South Pare was that children of the same gender (whether two, three or more) shared a room, and, as stated in Chapter 5, the direct costs of schooling at primary schools were low, and our sample did not include higher education than primary school. Thus, it is no wonder that the value of β_1 is low, suggesting that changes in welfare caused by changes in family size were low.

Regarding Table 6.4b, we confirm what we know from the literature[40], that the sensitivity parameter σ has no systematic relation to income and household size variables, but it depends completely on the individual character. In our case, both variables are non-significant, suggesting that the welfare sensitivity does neither depend on income nor on family size.

[40] Goedhart, Halberstadt, Kapteyn and Van Praag, (1977).

Finally, we estimated the extended model. Tables 6.5a,b present the estimation results for the subjective welfare function of equation (5). Adding personal variables, educational level, occupation, household consumption evaluated at monetary terms per month, scarce environmental products, and environmental degradation condition, to equation (5) improved the explanatory power of the model, indicated by the fact that adjusted R^2 was tripled.

The results in Table 6.5a show that, for both a husband and a wife, the individual welfare parameter μ_i significantly increased with an increase in household income, use of scarce environmental products, namely, fuel wood and water, and household consumption of the survey crops. The μ for husbands also increased with education, while, the μ for wives increased with having an occupation. The results further show that neither the environmental degradation situation nor the household size directly influenced the individual welfare parameter. Environmental degradation, however, indirectly influenced the individual welfare significantly through the quantity/volume of scarce environmental products used (that is, fuel wood and water).

The coefficients of the parameters of fuel wood and water were positive and significant at either $P < .01$ or $P < .05$, respectively. The variables were average quantity/volume in kilograms/litres of the environmental products consumed in the household per month. The coefficient of the parameter of household consumption was also positive and significant at $P < .05$. Since fuel wood and water are inputs in home-produced meals, an increase in household consumption induced an increase in the quantity and volume of these scarce meal-related inputs leading to higher opportunity costs which, in turn, would increase the want welfare parameter. This result suggests that with increased scarcity of environmental products the individual would need a higher income to maintain the same welfare level.

Table 6.5a. The subjective welfare function: Dependent variable is μ

Variable	(1) Husband		(2) Wife	
	Coef.	Std. err	Coeff.	Std. err
medium-degraded dummy[c]	0.03	0.08	-0.09	0.08
severely-degraded dummy[c]	0.06	0.10	-0.04	0.09
Education:				
Secondary education, dummy[b]	0.23	0.10**	-0.05	0.14
Occupation:				
Government employee, dummy[e]	-0.09	0.17	0.54	0.24**
Ln # household size	0.09	0.11	0.05	0.10
Ln household water in litres per month	0.18	0.07***	0.16	0.06**
Ln household fuel wood in kilograms per month	0.22	0.05***	0.22	0.05***
Ln monthly household income in Tshs[d]	0.06	0.02***	0.05	0.02**
Ln household consumption	0.05	0.02**	0.06	0.03**
Constant	1.33	0.59**	1.65	0.56***
Adjusted R^2	0.15		0.18	
N	301		301	

- * $P < .1$, ** $P < .05$, *** $P < .01$
- [b] = reference education level is " illiteracy"
- [c] = reference category: Non-degraded.
- [e] = reference occupation is "other"
- [d] = household income, as defined in the text, is the total income from all sources minus the monetary value of the home consumption of the survey crops.

Table 6.5b. The subjective welfare function: Dependent variable is σ

Variable	(1) Husband		(2) Wife	
	Coef.	Std. err	Coeff.	Std. err
medium-degraded dummy[c]	-0.02	0.05	-0.13	0.05
severely-degraded dummy[c]	0.29	0.06***	0.27	0.06***
Education:				
Secondary education, dummy[b]	0.08	0.06	-0.11	0.09
Occupation:				
Government employee, dummy[e]	-0.05	0.10	0.22	0.16
Ln # household size	-0.06	0.07	-0.10	0.07
Ln household water in litres per month	0.01	0.04	0.03	0.04
Ln household fuel wood in kilograms per month	0.14	0.03***	0.18	0.03***
Ln monthly household income in Tshs[d]	-0.01	0.01	-0.01	0.01
Ln household consumption	0.01	0.02	0.02	0.02
Constant	-0.11	0.35	0.40	0.38
Adjusted R^2	0.19		0.18	
N	301		301	

- * $P < .1$, ** $P < .05$, *** $P < .01$
- [b] = reference education level is " illiteracy"
- [c] = reference category: Non-degraded.
- [e] = reference occupation is "other"
- [d] = household income, as defined in the text, is the total income from all sources minus the monetary value of the home consumption of the survey crops.

Another result worth noting is the mother's occupation. The formal employment status of the mother in government offices significantly increased her want parameter. It has been noted throughout this thesis, especially in Chapter 4, that wives are key players in domestic chores. Taking the ceteris paribus condition, the absence of the mother during the day due to employment, would leave the household chores unattended if the schoolgirl in the household would not replace her mother. If the parents decided not to send the schoolgirl to school to fill the gap of the mother's absence, then the girls would be seriously affected in their educational attainment (see Chapter 5). However, in Chapter 5, we also found that the mother's literacy level generally had a positive and statistically significant effect on the educational attainment of the schoolchildren regardless of their gender, and would likely not tolerate to see her daughter affected in her educational attainment. The solution, therefore, would probably be to employ a house girl at a cost, which in turn, would increase household expenditures, demanding more income to maintain the current level of welfare.

Lastly, secondary education of the husband had a significant positive effect on his want parameter. Expectations were high for a male parent with education of at least secondary level. He was expected to improve household standard of living such as wealth and goods, all of which demanded an increase in income. If a household had cattle, a husband with this level of education would not want to herd the cattle himself. Since grazing is principally a man's job (see Chapter 3), he would need a hired servant to take care of the cattle, leading to a high want parameter, and consequently, demanding high income.

The results in Table 6.5b show that, for both a husband and a wife, the sensitivity parameter σ significantly increased with an increase in environmental degradation (severely-degraded) and an increase in the use of fuel wood. Recalling the fact that σ has something to do with welfare sensitivity, the results suggested that both parents became more sensitive to income as the use of fuel wood increased, and as the environment became more degraded. In a degraded environment, availability of natural resources varies substantially, due to fluctuations in rainfall. These circumstances induce relatively high variation in welfare over time, consequently leading to high values of σ .

6.5.2. Subjective well-being

Three separate sets of results are given in the upper part of Table 6.6 for husband (Column 1), wife (Column 2) and schoolchild (Column 3). The lower part of Table 6.6 shows Greene's post-estimation parameterization which provides both the coefficient estimate and the standard errors of the thresholds.

Subjective well-being, in all estimations, was found to be negatively influenced by environmental degradation. That is, living in a medium-degraded area, as compared with a non-degraded environment, significantly decreased the husband's well-being. A wife perceived lower well-being if she happened to live in a severely-degraded place, while a schoolchild felt unhappy living in either a medium or a severely-degraded environment. Chapter 3 already described that environmental degradation situation influenced the burden of labour (thereby affecting well-being) differently to each family member depending on their gender. Tables 3.2 and 3.9 of Chapter 3 testified that the environmental products collection and/or grazing activities were gender biased with husbands specializing in grazing while wives and children fetched both water and fuel wood. Living in a medium-degraded area made husbands spend more time in the predominantly male job of grazing than in any other environmental condition, thus making husbands feel relatively unhappy. The reason behind spending more time was the lack of grazing land on the hill, forcing husbands to take their herds of cattle downhill to the lowlands for pastures in the open commons. Given the nature of the landscape and slow movements of cattle up and down the hills, contributed to the long time spent on out-door grazing. Husbands in a non-degraded environment practiced indoor grazing with limited herds of cattle fed around the homesteads on available grass and crop residues. It is no wonder also that women living in a severely-degraded environment had a lower level of well-being than women in a non-degraded environment because the collection burden of scarce environmental products (fuel wood and water) was most obvious. For instance, women residing in a severely-degraded environment like *Ishinde, Njoro, Mgandu* and *Mvure-kongei* spent on average half of the daytime fetching fuel wood (see Table 3.3, Chapter 3). Note that the effect of a medium-degraded environment on the well-being of a wife was not significant. This was no coincidence, as it was already established in Chapter 3, that a wife being the principal-fuel wood collector, spent relatively little time in the medium-degraded environment compared to women in the non-degraded environment. This was due to the afforestation program at high altitudes accompanied with the effective by-laws of forbidding the villagers to harvest the newly flourishing-land cover in the neighbourhoods for domestic purposes. As for the schoolchild, the medium and severely-degraded environments significantly decreased the probability of well-being because, in whatever degradation condition, a child was subjected

to increase his/her time on grazing and fuel wood collection in assisting both parents. This is also reflected in the highly significant coefficient of fuel wood fetching time, negatively affecting the well-being of a schoolchild.

When exploring other determinants, household income had a significant positive influence on the husband's well-being, while the time he spent on domestic chores and the interaction of household size and income reduced his probability of well-being. Household chores were traditionally a female job, their increase would make a husband unhappy.

The well-being of a wife was significantly non-linear in the effect of age, decreasing after the age of 60.5 years (that is, solving for age, where $\frac{d}{d(age)} 0.121age - 0.001age^2 = 0$). Our study in the age aspect supports the trend found in Easterlin (2004) that happiness increases with age and then starts to decrease. Our study suggests an inverse 'age U-shaped relationship' for South Pare women whereas most of the 'western'[41] empirical findings suggest a U-shaped relationship. Our study is consistent with the work by Doyal (1990) who found that the situation of older women in underdeveloped countries is obviously different from women in the west in several ways. In the first place, relatively few survive to old age at all, and those who do are often severely debilitated by frequent childbearing and hard physical labour, and so, they spend their old life in pain and deteriorating health. Second, though they are more likely to be supported and looked after within the extended family, they feel unpleasant when putting too much of a burden on others. The results further show that the well-being of a wife in South Pare was also negatively associated with the time she spent on domestic chores and grazing, thus supporting the findings by Doyal (1990) that in the Third World many of women's health problems are associated with their heavy domestic responsibilities. On the other hand, while household income greatly increased the well-being of a husband, it marginally (almost insignificantly) made the wife happy. This is because, in the traditional setting, household income was subject to intra-household power dynamics. Women were less free to use the money as they wished because, in many families, men's dominance prevailed over family financial matters, and if women had private sources of own income, men sometimes would withdraw normal provisions for day-to-day household needs in the expectation that women's income would meet the deficit. Indeed, as Brockington (2001) noted, debates over the well-being status of women, especially in the rural areas, need to be cognizant of these intra-household contests.

Lastly, Greene's parameterization (lower part of Table 6.6) shows that all point estimates were highly significant. The results suggest that the determination of the well-being classification for a particular family member in our analysis suited the data, and statistically meaningful.

[41] See Clark and Oswald 1994, Oswald 1997, and Van Praag et al. 2000

Table 6.6. Estimation results: Ordered Probit:Dependent variable: Subjective well-being

Variable	(1) Husband		(2) Wife		(3) Schoolchild	
	Coef.	Std. err	Coeff.	Std. err	Coef	Std.err
medium-degraded dummy[c]	-0.51	0.24**	0.15	0..22	-0.75	0.24***
severely-degraded dummy[c]	-0.09	0.27	-0.51	0.23**	-1.10	0.30***
Ln # household size	2.04	2.82	2.33	2.84	6.01	2.98
Ln # (household size) squared	-0.33	0.81	-0.55	0.82	-1.71	0.86
Interaction term (ln # household size*ln monthly income)[d]	-0.28	0.10***	-0.14	0.10	-0.06	0.11
Ln monthly household income in Tshs[d]	1.17	0.36***	0.66	0.35*	0.44	0.39
Ln household consumption (in monetary value)	-0.02	0.07	-0.05	0.07	0.06	0.08
Ln household water in litres per month	0.02	0.18	-0.02	0.19	0.23	0.19
Ln household fuel wood in kilograms per month	0.09	0.15	-0.21	0.14	-0.83	0.17***
Ln # hours on domestic chores per month	-0.10	0.04**	-0.26	0.13**	-0.09	0.08
Ln # hours on agriculture per month	-0.01	0.10	0.12	0.13	0.20	0.07***
Ln # hours on grazing per month	0.00	0.03	-0.12	0.05**	0.03	0.07
Ln # Leisure hours per month	0.14	0.11	-0.00	0.06	0.00	0.14
Ln# hours on schooling per month	--	--	--	--	0.51	0.45
Age	0.02	0.05	0.121	0.06**	-0.02	0.30
Age squared	-0.00	0.00	-0.001	0.00**	-0.00	0.01
Ethnicity:						
Pare tribe, dummy[a]	-0.54	0.53	0.06	0.37	0.20	0.56
Chagga tribe, dummy[a]	-0.33	0.62	-0.46	0.48	0.55	0.67
Sambaa tribe, dummy[a]	-0.51	0.66	-0.20	0.50	0.15	0.72
Education - Adult:						
Primary education, dummy[b]	0.54	0.57	-0.26	0.64	--	--
Secondary education, dummy[b]	0.25	0.61	-0.68	0.76	--	--
Educational attainment -schoolchild:						
Falling behind, dummy[f]	--	--	--	--	-0.19	0.42
On time, dummy[f]	--	--	--	--	0.11	0.41
Occupation:						
Farmer, dummy[e]	0.16	0.40	-0.22	0.93	--	--
Government employee, dummy[e]	-0.52	0.55	0.18	1.04	--	--
Gender, dummy[g] -schoolchild	--	--	--	--	-0.01	0.15
Thresholds (cuts)	Coef.	Std. err	Coeff.	Std. err	Coef	Std.err
cut_1	3.52	3.35	1.17	3.73	2.77	4.02
cut_2	5.82	3.36	3.32	3.74	4.77	4.02
$LR\ \chi^2$	44.29		36.54		71.13	
$Prob > \chi^2$	0.003		0.027		0.000	
$Pseudo\ R^2$	0.09		0.07		0.15	
N	301		301		301	

Post – estimation: Greene's parameterization

Thresholds	Coef.	Std. err	Coeff.	Std. err	Coef	Std.err
cut_1	2.31	0.13***	2.15	0.12***	2.01	0.18***

Legend:

- $*P<.1$, $**P<.05$, $***P<.01$
- [c] = reference category: Non-degraded.
- [a] = reference tribe is "other".
- [d] = income, as defined in the text, is the total household income from all sources minus the monetary value of the home consumption of the survey crops.
- [b] = reference education level is " illiteracy"
- [e] = reference occupation is "other"
- [f] = reference attainment is "ahead"
- [g] = reference gender is "the schoolboy"

6.6. Conclusion

In this chapter, we have made an attempt to apply subjective measures of welfare and well-being in the context of rural Tanzanian South Pare highlands. To the best of our knowledge, this is the first attempt of its kind in Tanzania. Our results and ideas are still putty, and a long agenda of analyses is still to be done. This, *inter alia,* includes (1) an operating definition of income for developing countries like Tanzania where the concept "income" is not well-defined, particularly in rural areas, (2) testing for the endogeneity of income and other explanatory variables, (3) examining whether personal characteristics of the respondent as well as those of the household enter the welfare and well-being functions, and (4) solidifying the exact variables that fit both the welfare and well-being functions in a developing country context.

From our study we still can draw the tentative conclusions that,

(1) subjective welfare and well-being functions can be estimated and are empirically relevant even in a developing country context,

(2) in South Pare, using the sample data, the values of the want parameter were estimated at 4.46 for a husband and 4.39 for a wife; the values of the sensitivity parameter were estimated at 0.76 for a husband and 0.77 for a wife; and the values of utility of income were estimated at 0.05 for a husband and 0.06 for a wife,

(3) the value of the want parameter was found to be positively related to household size, household income, quantity/volume of environmental products used, occupation of the wife, and literacy level of the husband,

(4) subjective well-being was found to be negatively influenced by environmental degradation, the reference category being the non-degraded environment. Environmental products collection and/or grazing time negatively influenced the well-being of the family members depending on gender. The husband's well-being was affected by grazing, wives suffered from fuel wood fetching, and children were affected by both grazing and fetching activities. The well-being of the wife was age-dependent, decreasing after the age of 60.5 years. The household income greatly increased the well-being of the husband, and it marginally, almost insignificantly, made a wife happy,

(5) there is a strong linear dependency between the want parameter μ and the logarithm of income, and finally,

(6) there is a linear dependency between the sensitivity parameter σ, and environmental degradation and the use of fuel wood.

Given the fact that we get significant and intuitively interpretable results, it is justified to conclude that, with some refinements, the income evaluation question and the Gurin-question can be applied to measure subjective welfare and well-being of individuals in South Pare. The consequence is that this approach may become a useful new instrument for the evaluation and design of socio-economic policy in the area that faces environmental degradation.

CHAPTER 7

DISCUSSION AND CONCLUSIONS

7.1. Introduction

The rural South Pare highlands in Tanzania experience a deteriorating environmental situation (MTNRE, 1994; Semgalawe and Folmer, 2000). The causes of environmental degradation are cited as population growth (Kaoneka, 1994), deforestation, poor farming techniques, and weak forestry regulatory frameworks (Dewees, 1996). Of particular importance is the disappearance of forests and woodlands (Newmark, 1998). The consequences are declining amounts and diminished frequency of rainfall (Huwe, 1988), lower water levels and loss of biodiversity (Rodgers, 1993).

Deteriorating environmental resources increases the costs of collecting environmental products, which in many respects have no feasible close substitutes (Cavendish 1999; Dasgupta, 2001). One of the major components of the increased costs is labour time allocated by household members to collecting environmental products and/or grazing activities. This reallocation of intra-household labour resources may have different effects on welfare for different members of a household. In less developed communities like South Pare, in rural Tanzania, where private property rights are ill-defined or are biased against women, and where some of the markets are non-existent, degradation of the local environmental resource base is expected to adversely affect women and children more than men. Furthermore, labour time reallocation may interfere with labour allocated to other agricultural activities in the area. In addition, it could drain much of the time children allocate to schooling activities, which may have negative implications on their performance in schools and the quality of their human capital in the long run. Lastly, intra-household labour resource reallocation may influence the subjective economic welfare of the households.

Even though several studies have identified the extent of environmental degradation in Tanzania[42] very few (if any) formal economic studies have attempted to analyze the above effects. Moreover, very few studies in other countries have paid attention to the effects of scarcity of environmental products other than fuel wood (Kumar and Hotchkiss 1998; Bluffstone 1995; Mekonnen, 1998). Furthermore, these studies remain silent on the implications environmental degradation has on intra-household labour allocation and school progress. This study therefore presents an empirical analysis of these effects in South Pare, thus complementing other studies.

The analysis was based on cross-sectional data collected in 2006/2007 from households in Tanzania's rural South Pare highlands. South Pare is the most dramatic example of environmental degradation in Tanzania. The area is identified as having inadequate food production and deteriorating water supply, thus highlighting a state that needs immediate concern (Maghimbi 2007). The area is categorized into three main zones as per its geographical features, which influence the climate and associated agro-economy.

[42] See for example Campbell (1996), Dewees (1994, 1996), Holmes (1995), Sjöholm et al. (1995), URT (1998), Wily et al. (1995, 1996 1997, 1998), and Wily at el. (1999), Semgalawe (1998) and Semgalawe and Folmer (2000), Ilahi 2000, Sano 1996.

The zones are the Upland Plateau Zone (non-degraded area), the Middle Plateau Zone (medium-degraded) and the Lowland Zone (severely-degraded).

The study was guided by four hypotheses each of which were studied in empirical chapters of the thesis. The rest of this chapter proceeds as follows: Section 7.2 discusses the key findings based on the main objectives stated in Section 1.4 in conjunction with the hypothesis stated in Section 1.3. In each of the sub-sections of Section 7.2, the key findings are presented and the policy implication of each finding is concurrently provided. Section 7.3 summarizes the relevance of the study. Section 7.4 presents the limitations of this study and areas for further research.

7.2. Synthesis of the main findings

7.2.1. The deteriorating environmental resources have an "adverse impact"[43] on intra-household labour allocation.

The assessment of whether increased collection and/or grazing time due to environmental degradation alters the time-use patterns of each of the household members was accomplished in Chapter 3. We also examined the consumption of environmental products and the allocation of time across tasks and household members.

We applied the non-separable household model of the neo-classical agricultural household model (Singh, Squire, and Strauss, 1986; Heltberg *et al*., 2000). Since many individuals spent zero hours on some activities, we corrected for selection bias by using Heckman's two-steps estimation technique.

In the first place, the results showed that environmental products collection and/or grazing activities were gender biased with husbands specializing in grazing while wives and children were mainly fetching water and fuel wood. Secondly, we found out that environmental products collection and/or grazing time by the household members was, almost in all groups and in accordance with gender-biased activity, significantly influenced by the environmental conditions. Thirdly, we noticed that if a spouse or a schoolchild had participated in the intra-household activity, his/her time in the work had a significant impact on the time spent by the other spouse in that particular activity, especially in water and fuel wood fetching for domestic use. Lastly, individual characteristics like occupation, e.g., being a farmer or government employee, and ethnicity, e.g., being Pare or Chagga, generally had no significant impacts on the intra-household time-use of the household members in all collection and/or grazing activities.

Of the factors that influenced labour time patterns, environmental quality played a significant role in all estimates. The long hours spent on these collection and/or grazing activities had an impact on agricultural productivity, education of schoolchildren, welfare and well-being of the family members. These foreseen impacts are analysed in the subsequent sections. We therefore suggest that policies geared towards implementing projects that allow households to save time by increasing the availability of environmental products (e.g., forestry projects) or by allowing more efficient use of them (e.g., improved stove programs) are likely to be beneficial.

[43] Adverse impact refers to increased household labour allocated to collecting environmental products whose burden heavily falls on women and children as studies, among others, by Cooke (1998), Ilahi (2000) and Calvo (1994) have shown.

7.2.2. Environmental resource scarcity[44] leads to lower agricultural production and household consumption of home-produced meals.

In Chapter 4, we examined the influence of environmental degradation on both agricultural production and household consumption of the selected cereal crops, namely, maize, beans, millet and paddy. For regression and interpretation purposes, we combined the outputs of the four survey crops to get the total annual output that each household harvested for the agricultural year 2005/2006. The summing-up was inevitable because the survey crops were intercropped on the same field, thus, it was difficult to quantify the labour force, *proxied* by the work hours, applied to each crop separately. Consequently, since crop outputs weigh differently, we opted for the use of monetary value of their yields as a common scale in the regression equation. Regarding consumption, the amount of food cooked for consumption was expressed in calories per person, per day[45].

The basis for the theoretical framework was a neo-classical model of agricultural household production as described in Singh, Squire, and Strauss (1986). Viewed as a system of equations, our model included two endogenous variables, that is, total monetary value of agricultural outputs and total caloric intake, i.e., consumption by the family of these examined agricultural outputs. We estimated these equations with two-stage least squares (2SLS) to control for the endogeneity of production and consumption within households.

The results of the agricultural production equation showed that agricultural output of the four examined cereal staple-food crops was significantly related to consumption of these crops *proxied* by the total caloric intake, environmental degradation conditions, total cropped land, fertilizer application, ox-plough use and total income accrued from all sources minus the monetary value of their own domestic consumption.

Discussing the key findings, we found that fertilizer use and ox-plough effects had highly significant positive effects. As expected, their application increased the cereal production in the area. An increase in household size also increased the output significantly. In South Pare, human labour using a hand hoe was the basic level of agricultural mechanization. An increase in family size would supply extra human power to extend the size of the cropped land which would, in turn, increase the output, *ceteris paribus*.

The results further showed that staples production in the area was highly responsive to the cropped area, as expected. As the peasants increased the cropped land size, also crop production increased, *ceteris paribus*.

The most interesting results concerned the impact of environmental degradation conditions on agricultural output. As expected, the results were highly significant, but to our surprise, favoured severity of environmental degradation. Technically, the estimates suggested that as the environment became either medium or severely-degraded, the agricultural production increased. This is a paradox because from the theoretical framework we expected the opposite to be true. A logical understanding of the estimates, however, was

[44] The scarce environmental resources here refer to fuel wood, grass and water.

[45] The average per capita daily calorie supply is derived by dividing the total calories obtained from the daily consumption of various meals in the household by the household size. The formula for computing the caloric intake is given in the estimation techniques (Section 4.4). The calorie supplies are reported in kilocalories.

given in the data descriptive part (Section 4.3) showing that the survey crops (maize, beans, millet and paddy) were cereals, which biologically yield better in either the lowland or the medium plateau land than at high altitudes where the environment is non-degraded (Maghimbi, 2007).

With regard to household production, the results indicated that consumption of the survey crops, *proxied by* caloric intake, was significantly related to agricultural output, environmental degradation, household income, the interactions of degraded environment conditions and income, and household size.

Examining in detail each of the significant variables, we saw that the survey crops output, a proxy for agricultural production, had a significant positive effect on caloric intake, i.e., consumption of the same selected dietary staples. This result implied that consumption tracks production. However, the elasticity of total consumption with respect to the gross value of the survey crops equalled 0.22 suggesting that, around the mean of the dietary staples production, a one percent increase in cereal crop production would lead to a small increase in consumption of only 0.22 percent. The other produce then is either sold to meet household cash demand or is stocked for precautionary purposes pending for the next harvest. Since, geographically the survey crops grow relatively well in the medium and lowlands where there are no alternative cash crops, and the economy itself is subsistence with less stocks, we tend to believe that much of the produce was sold to cater for the household's financial expenditures. Our belief was supported by the negative sign of the income parameter.

The interactions of the environmental degradation situations and income (the categorical reference being the non-degraded environment)were also significant and positive; suggesting that the consumption level of the survey crops was influenced by the household income differently at different levels of environmental degradation.

The other positive effect was on household size. As household size increased, consumption also increased because of more mouths to feed.

To conclude, both descriptive and regression results indicated that there were strong possibilities that environmental degradation was limiting the production and consumption potentials in the area and that limited adoption of agricultural modernization further aggravated this problem.

Strategies designed to preserve the natural resource base would be recommended in view of long-run benefits. Short-run strategies would include improving production technologies and persuading household members to grow drought-resistant crops. Consequently, household members should change their consumption behaviour of eating certain preferred staples into alternatives that have a better chance of being produced like cassava, sorghum and sweet potatoes. The long-run and much so, the short-run strategies should be carried out locally. Moreover, the strategies should be aimed at small farmers, who are nutritionally at risk.

7.2.3. The school attendance and progress of children in rural primary schools, with respect to their gender, is inversely affected by deteriorating environmental resources.

In the preceding chapters we showed that schoolchildren were involved in the work, supporting their households' livelihoods, including housework, farming, collecting scarce

environmental product and/or grazing. This type of child labour frequently led to foregone schooling, which might have critical consequences for educational achievements. While there were a number of factors that might affect attendance and school progress at the primary level, the question of how important children's work was in determining whether or not they attended school and attained desired progress at school remained. Chapter 5 attempted to consider this factor as far as it resulted from environmental degradation.

School attainment was considered an ordinal dependent variable, indicating a ranking of school attainment. Since the values of such an ordered school progress are arbitrary and are a function of a set of explanatory factors, we used ordered probit estimation techniques.

The results showed that the probability of educational attainment at primary school, was found to be significantly associated with age, age-squared, and the mother's secondary education. The formal employment status of the mother in the government offices significantly, but differently, affected the probability of educational attainment of both the schoolgirl and the schoolboy separately, but not in the pooled estimates. The household ethnicity, i.e., being Sambaa as compared to other tribes, significantly decreased the probability of schoolgirls' progress at primary school. The basic literacy of the mother at primary education level, the cropped land size, and the interaction term of the medium-degraded environment and the household annual income increased, at a lesser significant level, the probability of schoolboys' progress at school. Interestingly, a severely-degraded environment, in reference to the non-degraded area, significantly decreased the probability of schoolgirls' progress at school. However, environmental degradation had a significant impact neither on schoolboys' educational attainment, nor on the attainment of the schoolgirls and schoolboys pooled together. Thus, for our sample, environmental degradation and the time spent on collecting the scarce environmental products *proxied* by the average kilograms of fuel wood and litres of water used in the households per week had no common effect on the school attainment of the schoolchildren pooled together as it was previously thought to be.

Discussing the results separately in detail, we found that both the age of the schoolchild and the age-squared were statistically significant. This implied that there was a significant non-linearity in the effect of age of the child on school attainment, decreasing after the age of 6.5 years. That is, the older the children became, the more they lagged behind. We obtained similar effects for the gender-specific estimates. The descriptive results in Chapter 5 supported this estimation result. In our sample, we had schoolchildren in the 15 – 19 years age group who were still at primary school, suggesting that there was late entry and grade repetition, and thus not enough progress in the grade-for-age school attainment. Some schoolchildren in the 7 – 13 age cohort were not in their proper grades, indicating that they were lagging behind in educational attainment. Descriptive results showed that only 51.2 percent of the attending schoolchildren started grade 1 at the right age of 7 as required by the educational system in Tanzania. However, environmental degradation did not affect delays in school attainment because of environmental products collection and/or grazing, work at home, and work on the farms. Each of these factors contributed at most 5 percent in explaining the variation in total primary school late entry.

The mother's literacy level generally had a positive and statistically significant effect on the educational attainment of the schoolchildren regardless of their gender. While the mother's secondary education significantly increased the probability of both the girls'

and the boys' progress at school, the basic literacy of the mother at the primary education level significantly increased the educational attainment of the boys only. The effects were quite strong, suggesting that education is an investment good in the sense that the parents (in our case, mothers) invested in their children's education so that their children would have better life chances and so their offspring would be best placed to support them in later life. The schoolboys' education was favoured even by mothers with just primary education because, culturally, the boys are coheirs of the family properties. Thus, education would place them in an outstanding position to manage prudently the inheritance afterwards, consequently enhancing the parents' utility. On the other hand, however, as would be expected, cultural preferences in terms of attitudes towards education negatively affected the girls' educational attainment. Girls belonging to the Sambaa, compared to the other tribes living in South Pare (like Pare and Chagga), showed significantly lower probability of grade-to-age educational attainment. This implied that the Sambaa tribe probably did not value human capital formation of girls highly as the girls would get married and might shift to the would-be husbands' clan who, in turn, would benefit from the educational investment previously made by the girls' parents.

Lastly, the formal employment status of the mother at a government office significantly decreased the probability of educational attainment for schoolgirls, whereas the probability of educational attainment for schoolboys was significantly enhanced. Taking the ceteris paribus condition, the absence of the mother at home during the day due to employment, would leave the household chores unattended if the schoolgirl in the household would not replace her mother. If they decided not to send the schoolgirl to school to fill in the gap of the mother's day absence at home, then, the girls would be affected much more than the boys in educational attainment.

To conclude, our basic interest in this section was to test whether school attendance and progress of children in rural primary schools, with respect to their gender, was inversely affected by deteriorating environmental resources. Our basic findings showed that there were other factors that significantly affected the probability of school attainment for the schoolchildren apart from environmental degradation. Firstly, girls and boys spent, on average, the same number of hours per week in school activities across environmental conditions. Secondly, deteriorating resources like environmental products collection and/or grazing, work at home, and work on the farms, each contributed only marginally (less than 5 percent) in explaining the variation in primary school late entry, negatively affecting the girls only.

Furthermore, although our estimations had satisfactory explanatory power in explaining educational attainment, the Pseudo-R^2 might be improved by adding school crowdedness, illness, bad weather, school quality, absenteeism due to street vending, etc. These factors were equally important factors for late school entry, and consequently, for the delay in the grade-to-age school attainment.

In their attempt to improve educational attainment at primary level, policy makers therefore should as well, focus on these relevant factors, which were excluded from our model due to lack of data. For the government to be able to fund the learning facilities, the growth of the economy is an important aspect. Policy makers thus need to devise overall strategies that would guarantee high economic growth rates in both the medium and long term, which in turn, will increase the budgetary allocations to the education sector to cater

for both recurrent and capital expenditures. Moreover, the non-government sector may also be enticed into investing in education through attractive fiscal incentives.

7.2.4. Household subjective economic welfare is inversely affected by deteriorating environmental resources.

7.2.4.1. Subjective economic welfare

The first objective of Chapter 6 was to study the individual welfare function in South Pare. Our interest in this respect was on the survey answers from the "income evaluation question" (IEQ). We estimated for each individual the own income evaluation by filling in the reported income into his/her welfare function. The average estimated values of the individual want parameter μ denoting the log-income evaluated at 0.5 on the [0,1] welfare scale were found to be 4.46 for husbands and 4.39 for wives. The income numerals in the dataset are in thousands Tanzanian Shillings, hence 86,487 Tanzanian Shillings for a husband and 80,640 Tanzanian Shillings for a wife was considered as insufficient, respectively. Meanwhile, the official Government minimum wage in 2006/2007 was 75,340 Tanzanian Shillings per month. This means that individuals in South Pare clearly considered the official minimum wage per month as insufficient. The values of the sensitivity parameter σ of the welfare function were 0.76 for husbands and 0.77 for wives, suggesting that husbands and wives had equally steep welfare functions.

We first estimated the welfare function with only two determinants of the individual want parameter μ of welfare, namely household income I and household size H. The estimation results showed that the values of the preference drift and the household size elasticity for husband and for wife were positive, and highly significant, suggesting that they significantly increased the individual want parameters of both wife and husband.

The values of the household size elasticity were small (0.29 and 0.28). Theoretically, the value of the household size elasticity is an indication for the change in welfare caused by a change in the family size, at the margin. If we had a family where each child had to have his/her own room, study at the university, etc., then we would expect to have a high family size elasticity. But, the reality in South Pare was that children of the same gender (whether two, three or more) shared a room, the direct costs of schooling at primary schools were low, and our sample did not include higher education than primary school. Thus, the value for family size elasticity was low, suggesting that changes in welfare caused by changes in the family size were low.

Finally, we estimated the extended model. Adding personal variables like educational level, occupation, household consumption evaluated at monetary terms per month, scarce environmental products, and environmental degradation condition to the function, improved the explanatory power of the model by threefold.

The results of the extended model showed that, for both a husband and a wife, the individual welfare parameter μ_i significantly increased with an increase in household income, use of scarce environmental products namely, fuel wood and water, and household consumption of the survey crops. The μ for the husband alone also increased with education, while the μ for the wife alone increased with having an occupation.

The coefficients of the parameters of fuel wood and water were positive. The variables were average quantity/volume in kilograms/litres of the environmental products consumed in the household per month. Taking the ceteris paribus condition, the results

showed that the increase in the use of these scarce environmental products would obviously lead to higher opportunity costs, which, in turn, would increase the want parameter, suggesting that the individual would need higher income to maintain the same welfare level. The amount of money (e^{μ}) that the individual in the household would need to maintain the current welfare might be interpreted as the cost induced by environmental degradation.

The other result worth noting was the mother's occupation. The formal employment status of the mother in government offices significantly increased her want parameter. It had been noted throughout this thesis, especially in Chapter 4, that wives were key players in domestic chores. Taking the ceteris paribus condition, the absence of the mother at home during the day due to employment, would leave the household chores unattended if the schoolgirl in the household would not replace her mother. If the parents decided not to send the schoolgirl to school to fill in the gap of the mother's day absence at home, then, the girls would be seriously affected in educational attainment (see Chapter 5). However, in Chapter 5, we also found that the mother's literacy level generally had a positive and statistically significant effect on the educational attainment of the schoolchildren regardless of their gender, and would likely not tolerate to see her daughter affected in educational attainment. The solution, therefore, would probably be to employ a house girl at a cost, which in turn, would increase household expenditures, demanding more income to maintain the current welfare level.

Lastly, secondary education of the husband had a significant positive effect on his want parameter. Expectations were high for a male parent with education of at least secondary level. He was expected to improve household standard of living such as wealth and goods, all of which demanded an increase in income. If a household had cattle, a husband with this level of education would not want to herd the cattle himself. Since grazing was principally a man's job, he would need a hired servant to take care of the cattle, leading to a high want parameter, and consequently, demanding high income.

7.2.4.2. Subjective well-being

The well-being equation was estimated by means of an ordered probit because we assumed that subjective well-being (SWB) was a categorical variable and that the answer to the subjective well-being question provided an ordinal ranking. The ordinal interpersonal comparability was also assumed. This means, for example, that an individual answering "3" in the well-being question, was more satisfied or happier than one answering "1", but not necessarily three times as happy or satisfied.

The results showed that subjective well-being was negatively influenced by environmental degradation. That is, living in a medium-degraded area, as compared with a non-degraded environment, significantly decreased the husband's well-being. A wife perceived lower well-being if she happened to live in a severely-degraded place, while a schoolchild felt unhappy living in either a medium or a severely-degraded environment. Chapter 3 already described that environmental degradation influenced the burden of labour (thereby affecting well-being) differently to each family member depending on the gender of a person.

Household income had a significant positive influence on the husband's well-being, while the time he spent on domestic chores and the interaction of household size and

income reduced his probability of well-being. Household chores were traditionally a female job, their increase would make a husband unhappy.

The well-being of a wife was significantly non-linear in the effect of age, decreasing after the age of 60.5 years. Our study suggests an inverse 'age U-shaped relationship' for South Pare women whereas most of the 'western'[46] empirical findings suggest a U-shaped relationship. Our study is consistent with the work by Doyal (1990) who found that the situation of older women in underdeveloped countries is obviously different from women in the west in several ways. In the first place, relatively few survive to old age at all, and those who do are often severely debilitated by frequent childbearing and hard physical labour, and so, they spend their old life in pain and deteriorating health. Second, though they are more likely to be supported and looked after within the extended family, they feel unpleasant of putting too much of a burden on others.

The results further showed that the well-being of a wife was also negatively associated with the time she spent on domestic chores and grazing, thus supporting the findings by Doyal (1990) that in the Third World many of women's health problems are associated with their heavy domestic responsibilities. On the other hand, while household income greatly increased the well-being of a husband, it marginally (almost insignificantly) made the wife happy. This is because, in the traditional setting, household income was subject to intra-household power dynamics. Women were less free to use the money as they wished because, in many families, men's dominance prevailed over family financial matters, and if women had private sources of own income, men sometimes would withdraw normal provisions for day-to-day household needs in the expectation that women's income would meet the deficit. Indeed, as Brockington (2001) noted, debates over the well-being status of women, especially in the rural areas, need to be cognizant of these intra-household contests.

To conclude this section, we say that this is the first attempt to apply measures of subjective welfare and well-being in the context of the rural Tanzanian South Pare highlands. Still there is a long agenda of analyses to be done, including, *inter alia,* (1) an operating definition of income for developing countries like Tanzania where the concept "income" is not well-defined, particularly in rural areas, (2) testing for the endogeneity of income and other explanatory variables, (3) examining whether personal characteristics of the respondent as well as those of the household enter the welfare and well-being functions, and (4) solidifying the exact variables that fit both the welfare and well-being functions in a developing country context.

Given the fact that we get significant and intuitively interpretable results, it is justified to conclude that, with some refinements, the income evaluation question and the well-being question can be applied to measure the subjective welfare and well-being of individuals in South Pare. The consequence is that the subjective measurement approach may become a useful new instrument for the evaluation and design of socio-economic policy in the area that faces environmental degradation.

[46] See Clark and Oswald 1994, Oswald 1997, and Van Praag et al. 2000

7.3. Relevance of the findings

This study is instrumental in understanding and setting proper measures towards solving the problems of sustainable development, poverty alleviation, environmental policy and the position of women. This is because, we hope, the study has:

1) contributed to our understanding of the determinants of intra-household labour resource allocation, and that the environmental products collection and/or grazing activities are gender biased and that the labour time allocation is significantly influenced by environmental condition;
2) pointed out that environmental degradation, is limiting the production and consumption potentials in the area and that limited adoption of agricultural modernization further aggravates this problem;
3) shown how women and children fall victim to the intra-household labour resource allocation under prevailing environmental degradation and that gender targeting could enhance welfare of each member of the household; and,
4) provided a strong stimulus for the development and implementation of environmental policy (e.g., forestry projects) and campaigning for more efficient use of the environmental products through improved stove programs because of the negative impacts of environmental degradation on agricultural and household production, on investment in human capital, and on the welfare and well-being of individuals in the area.

We also believe that the results from this study may spearhead various policies in Tanzania and in other developing countries that rely on the natural resource base in the face of environmental degradation.

7.4. Limitations of this study and areas for further research

Our study used cross-sectional primary data. The cross-sectional study design was ideal because the research period was only one year. Within the given research period, it was possible to find out the prevalence of the environmental degradation phenomenon and its effects on the intra-household labour resource allocation, agricultural and household production, child school attainment, and on subjective welfare and well-being. It is an overall picture as it was at the time of the study. Among the variables which are basically annual, there is just one agricultural season[47] in the area per annum that we covered in this study. The results lead to interesting insights, but part of these insights would require a substantially longer period of observation to determine the pattern of change in relation to time, for which a longitudinal design should be used.

A second drawback is the methodology for measuring time allocation to various collection and/or grazing activities. We employed a recall survey method, which may give room for either overestimation or underestimation of the time spent on a particular activity. This is because some household members did not, in their day-to-day affairs, find it necessary to quantify time. Moreover, some of them did not have watches. Their time measurement was based on time-aids such as experience, sun-sight and regular time

[47] Crops grown in the previous agricultural season for both sale and home consumption were investigated by means of questionnaires.

announcements on radio broadcasts. However, we tried to overcome the drawback in time measurement by comparing to hours reported in others studies[48] in the semi-arid areas of central Tanzania like Dodoma and Singida where environmental degradation is also noticeable.

A third limitation is the limited number of variables in the analysis of the educational attainment of schoolchildren. Although our estimations had satisfactory explanatory power, the explained variance might be improved in future research by adding school crowdedness, illness, bad weather, poor school quality, and school absenteeism due to street vending. These factors were equally important for late school entry, and, we believe, might also influence the delay in the grade-to-age school attainment.

Lastly, a limitation of our research calls for further research into subjective welfare and well-being. The focus, *inter alia,* should include (1) an operating definition of income for developing countries like Tanzania where the concept "income" is not well-defined, particularly in rural areas, (2) testing for the endogeneity of income and other explanatory variables, (3) examining whether personal characteristics of the respondent as well as those of the household enter the welfare and well-being functions, and (4) solidifying the exact variables that fit both the welfare and well-being functions in a developing country context.

[48] Some of these studies are Sieff, (1997), Kabatange, Rukantabula, and Kitalyi, (1984) and Johnsen, (1999).

APPENDIX I

HOUSEHOLD SURVEY QUESTIONNAIRE

We are conducting research on *Environmental Degradation and Intra-household Welfare: The case of the Tanzanian rural South Pare Highlands*. The research requires conducting interviews with various stakeholders including your family. The information hereby obtained is solely for academic reasons and all your responses will remain confidential. We will try our best to share the results of our research with you once completed. We will be extremely grateful if you agree to collaborate with us and give some of your time to answer a set of questions we have. The questions are designed to help us understand how deteriorating environmental resources influence intra-household labour allocation, agricultural and household production, school attainment of school-age children, and subjective welfare and well-being of the family members. For a deeper insight in the matter, other factors like family characteristics and family income are analyzed. We thank you for your time and eagerly hope for your cooperation.

IDENTIFICATION

HOUSEHOLD NAME/NUMBER …….
NAME OF HOUSEHOLD HEAD …. ……
NAME OF THE VILLAGE ……..……..…
Ward ……..……..…
District ……..

DATE OF INTERVIEW …… ……. …….
Day Month Year
INTERVIEWER ……..
RESPONDENT:
FATHER ……ETHNICITY…….……..

MOTHER……ETHNICITY……

Important: *Questions that need general household information may be answered by either both spouses together or by the head of the household. Otherwise, each respondent must try to answer each question alone.*

I. HOUSEHOLD CHARACTERISTICS

1. Please classify the household members under the following:

No.	1A. List names of individuals including yourself that live in this household ordered by age.	1B. What is the sex of **X**? Male 1 Female 2 ***code***	1C. How old is **X**? ***Years***	1D. What is X's relationship to the household head? ***code***	1E. What is **X**'s education level? ***code***	1.F. What is **X's** occupation? ***code***
1						
2						
3						
4						
5						
6						
7						
8						
9						

Note: List all the people in the household first and then ask questions 1B to 1F.

Codes for question 1D.

Head	1	Step son/step daughter	6	Sister/brother-in-law	11
Wife/husband	2	Step father/step mother	7	Nephew/nice	12
Son/daughter	3	Grand child	8	Uncle/aunt	13
Father/mother	4	Grand parent	9	Cousin	14
Sister/brother	5	Father/mother-in-law	10	Other (specify)	15

Codes for question 1E.

Illiterate, no schooling	1	Secondary education	3	University	5
Primary education	2	Vocational training	4	Other (specify)	6

Codes for question 1F.

Farmer	1	Private sector employee	3	Retired	5	Business	7
Government employee	2	Unemployed	4	Pupil/student	6	Other (specify)	8

II. ENVIRONMENTAL PRODUCTS

In this section we are going to talk about water, cut grass/grazing and fuel wood collected and used by this household for different purposes.

A. WATER

General household information – these questions may be answered by either both spouses together or by the head of the household.

1. What is the source of water used most often in this household for things like drinking, cooking, domestic animals and other domestic purposes?

PIPED WATER	1	FLOWING RIVER/STREAM	3	SPRINGS	5
BOREHOLE	2	DAM/STAGNANT WATER	4	OTHER	6

2. How much water on average does this household need daily? LITRES[49] ☐

Individual information – these questions must be answered by each spouse alone.

3. On average how many hours in a day do you spend on fetching water (include time spent waiting in queue)?

	FATHER	MOTHER
Hours per day		

4. How many days in a week do you go out to fetch water for household use?

	FATHER	MOTHER
Number of days in a week		

5. Does this work sometimes prevent you from doing other production activities like farm and/or house work?

FATHER	MOTHER

YES 1
NO 2

6. If YES, How much did you have to reallocate your time for other production activities within the last 12 months because of spending too much time on water collection?

FATHER	MOTHER

OFTEN 1
SELDOM 2
NEVER 3

7. In which season[50] last year did you have to reallocate your time for other activities most often so that you could fetch water for your household?

FATHER	MOTHER

RAINY SEASON 1
DRY SEASON 2

8. Normally, how many litres of water do you carry per trip?

	FATHER	MOTHER
Litres of water		

B. FUEL WOOD/CHARCOAL

General household information – these questions may be answered by either both spouses together or by the head of the household.

[49] If they use plastic containers, usually a big container has a volume of 20 litres while the small one carries 10 litres.

[50] There are two seasons in a year. The rainy season is in March, April, May, October, November and December while the dry season takes place in January, February, June, July, August and September.

1. What is the main source of energy this household uses for different purposes like cooking, space heating and local brewing?

FUEL WOOD/CHARCOAL	1
ELECTRICITY	2
GAS	3
SOLAR POWER	4
KEROSINE	5

2. How much fuel wood/charcoal on average does this household need daily?

KGS

3. If fuel wood and/or charcoal is the main source of energy, where is the source of fuel wood this household depends most on?

NATURAL FOREST	1
PLANTED FOREST	2

Individual information – these questions must be answered by each spouse alone.

4. On average how many hours in a day do you spend on collecting fuel wood (include time spent on travelling)?

	FATHER	**MOTHER**
Hours in a day		

5. How many days in a week do you go out to collect fuel wood for household use?

	FATHER	**MOTHER**
Number of days in a week		

6. Does this work sometimes prevent you from doing other production activities like farm and/or house work?

YES	1
NO	2

FATHER	**MOTHER**

7. If YES, How much did you have to reallocate your time for other production activities
within the last 12 months because of spending too much time on fuel wood collection?

OFTEN	1
SELDOM	2
NEVER	3

FATHER	**MOTHER**

8. In which season last year did you have to reallocate your time for other activities most often so that you could fetch fuel wood for your household?

RAINY SEASON	1
DRY SEASON	2

FATHER	**MOTHER**

9. Normally, how many kilograms[51] of fuel wood/charcoal load do you carry per trip?

	FATHER	MOTHER
Kgs of fuel wood		

C. CUT GRASS/GRAZING

General household information – these questions may be answered by either both spouses together or by the head of the household.

1. Do you keep animal like cows, goats, and sheep that need grass as part of their diet in this household?

YES 1
NO 2

2. If YES, do you take out these animals everyday for grazing?

Individual information – these questions must be answered by each spouse alone.

3. On average how many hours in a day do you spend on grazing these animals?

	FATHER	MOTHER
Hours in a day		

4. How many days in a week do you spend on grazing ?

	FATHER	MOTHER
Number of days in a week		

5. Does this work sometimes prevent you from doing other production activities like farm and/or house work?

YES 1
NO 2

FATHER	MOTHER

6. If YES, How much did you have to reallocate your time for other production activities within the last 12 months because of spending too much time on grazing?

OFTEN 1
SELDOM 2
NEVER 3

FATHER	MOTHER

[51] The weight in kilograms will be estimated depending on the size of the fuel wood bundle an individual is normally able to carry in each trip

7. In which season last year did you have to reallocate your time for other activities most often so that you could go on grazing?

RAINY SEASON 1
DRY SEASON 2

FATHER	MOTHER

III. AGRICULTURAL PRODUCTION

General household information – these questions may be answered by either both spouses together or by the head of the household.

1. In the past 12 months, did this household grow crops for sale or home consumption?

YES 1
NO 2

2. If YES, mention four major crops cultivated and harvested, the size of land cultivated for each crop and output harvested in the past year?

No.	Crop name	acres	Harvest (# sacks/kgs)	
			# sacks[52]	Total weight (kgs)
1				
2				
3				
4				

3. Does this household use any tractors or other farming vehicles in farming production?
(owning or hiring)

YES 1
NO 2

4. Does this household apply any other mechanized farm equipments like water pumps and sprinklers in farming production?
YES 1
NO 2

5. If YES, mention the applied mechanized farm equipments in this household

No.	equipment

[52] A big sack fully filled with either maize, millet or beans is estimated to have a weight of 100 kilograms. A sack of paddy of the same nature is approximated to have a weight of 80 kilograms.

6. Does this household use fertilizer in farming production?

YES 1
NO 2 ☐

7. If YES, what kind of fertilizer does this household use most?

Organic fertilizers	
Inorganic fertilizers	
Both	

8. Does this household use animal services like oxen for ploughing?

YES 1
NO 2 ☐

Individual information – this question must be answered by each spouse alone.

9. On average, you personally, how much time daily do you spend on farming?

	FATHER	**MOTHER**
Hours per day		

IV. HOUSEHOLD PRODUCTION

Individual information – these questions must be answered by each spouse alone.

1. Do you engage on any of the following household activities? If YES, write number one (1) in the box provided. If NO, write zero (0).

ACTIVITY	**FATHER**	**MOTHER**
Cooking		
Child care		
Cleaning		

2. On average, you personally, how much time daily do you spend on the above mentioned household activities?

	FATHER	**MOTHER**
Hours per day		

General household information – these questions may be answered by either both spouses together or by the head of the household.

3. In this household, how many times a day do you have home prepared meals for family members? TIMES ☐

4. On normal circumstances, based on your staple food, what food types and in what measure compose a main family meal?

No.	Food type	Local measure eg. # tins /kgs	
		# tins	Total weight (kgs)
1			
2			
3			

V. HOUSEHOLD INCOME

General household information – these questions may be answered by either both spouses together or by the head of the household.

1. On average, how much did the household earn from various sales (crops and animals) last production year? TSHS ☐

2. Please mention the total income received into the household from wage employments of each household member in each month.

No.	Household member (name)	Hours paid for per day	Amount earned per day/month (Tshs)
1			
2			
3			
4			
5			
6			
Total			

3. Please mention the total income received into the household from other various non-employment sources like pension payments, charity, grants and insurance in the last 12 months.

TSHS ☐

Total household income (V.1 + 2 + 3) TSHS ☐

VI. SUBJECTIVE ECONOMIC WELFARE AND WELL-BEING

Individual information – these questions must be answered by each spouse alone.

1 Taking everything into account, how satisfied are you in this household with the way the household lives these days? Choose one response.

		FATHER	MOTHER
Very dissatisfied	1		
Dissatisfied	2		
Satisfied	3		

2. Which monthly household after-tax income would you consider to be very insufficient? insufficient? sufficient?

		FATHER	MOTHER
VERY INSUFFICIENT	if it were about Tshs		
INSUFFICIENT	if it were about Tshs		
SUFFICIENT	if it were about Tshs		

Thank you for your cooperation.

APPENDIX II SCHOOLCHILD SURVEY QUESTIONNAIRE

We are conducting research on *Environmental Degradation and Intra-Household Welfare: The case of the Tanzanian rural South Pare Highlands*. The research requires conducting interviews with various stakeholders including YOU on your schooling background, school participation, agricultural production participation, household production participation and collection of scarce environmental products such as fuel wood, cut grass and water. The information hereby obtained is solely for academic reasons and all your responses will remain confidential. We will try our best to share the results of our research with you once completed. We will be extremely grateful if you agree to collaborate with us and give some of your time to answer a set of questions we have. The questions are designed to help us understand how your school attainment is inversely affected by the deteriorating environmental resources. We thank you for your time and eagerly hope for your cooperation.

IDENTIFICATION

LOCALITY NAME …….
NAME OF HOUSEHOLD HEAD ……
NAME OF THE VILLAGE ……..……...…
Ward ……..……..…
District ..……...……..

DATE OF INTERVIEW …… ……. …….
Day Month Year
NAME OF CHILD ……..……

Relationship with the household head:

MOTHER/FATHER	1
STEP/FOSTER PARENT	2
GRAND PARENT	3
SISTER/BROTHER	4
AUNT/UNCLE	5
SISTER/BROTHER-IN-LAW	6
OTHER RELATIVE	7
NOT RELATED	8

INTERVIEWER'S NAME…….

I. SCHOOLING BACKGROUND AND SCHOOL PARTICIPATION

1. What is your age now?

2. What grade in primary school are you attending now?
CODES
P1 P2 P3 P4 P5 P6 P7

3. What is the name of the primary school you attended last academic year?

4. In Tanzania, children start primary school at age 7. How old were you when you first attended P1?

YEARS ☐

5. If you got delayed, please tell me the major reason that explain why you started school later than age 7.

ILLNESS	1
WORK AT HOME	2
INABILITY TO PAY FEES	3
SCHOOL CROWDED	4
WORK ON THE FARMS	5
OTHER (specify……)	6

☐

6. Have you attended school during the past 12 months?
YES …….1
NO……2

7. Every child misses school once in a while. How much did you miss school within the last 12 months?

OFTEN	1
SELDOM	2
NEVER	3

8. In which season did you miss school most often other than regular vacations and holidays?

RAINY SEASON	1
DRY SEASON	2

☐

9. Why did you miss school during this/these month(s)?

COLLECTING ENVIRONMENTAL PRODUCTS	1
WORKING AT FARMS	2
WORKING AT HOME	3
LACK OF SCHOOL FEES/CONTRIBUTIONS	4
LACK OF STATINERY	5
ILLNESS	6
BAD WEATHER eg. Rain	7
OTHER (specify…….)	8

☐

10. Now I would like to ask you about the time you spend at school. On a normal school day, at what time do you leave home to go to school?

Hour		
Min		

11. On a normal school day, at what time do you return home from school?

Hour		
Min		

12. I would like to ask you about your homework. About how many hours per day do you spend doing homework outside of school?

Hour per day		

II. PARTICIPATION ON COLLECTING ENVIRONMENTAL PRODUCTS

1. Apart from attending school on normal school days, do you also spend some time to help your parents/guardians collecting environmental products like fuel wood, cut grass and water?
   YES 1
   NO 2

2. If YES, on average how many hours in a day do you spend on collecting environmental products?

Hour per day		

3. Does this work sometimes prevent you from going to school?
   YES 1
   NO 2 [ ]

4. If YES, How much did you miss school within the last 12 months because of helping your parents/guardians in collecting environmental products?
   OFTEN 1
   SELDOM 2
   NEVER 3

5. In which season did you miss school most often so that you could collect environmental products for your household?
   RAINY SEASON[53] 1
   DRY SEASON 2

6. Normally, how many kilograms[54] or litres[55] of either fuel wood load or water basket do you carry per trip? Kgs [ ] Ltrs

III. PARTICIPATION ON AGRICULTURAL PRODUCTION

1. Some children do help their parents/guardians with farm work like cultivating, sowing, Weeding, harvesting and tending animals on normal school days. Do you also do the same?
   YES 1
   NO 2
2. If YES, on average how many hours in a day do you spend on farm activities?

Hour per day		

3. Does this work sometimes prevent you from going to school?
   YES 1
   NO 2 [ ]

[53] There are two seasons in a year. The rainy season is in March, April, May, October, November and December while the dry season takes place in January, February, June, July, August and September.

[54] The weight in kilograms will be estimated depending on the size of the fuel wood bundle an individual is normally able to carry in each trip

[55] If they use plastic containers, usually a big container has a volume of 20 litres while the small one carries 10 litres

4. If YES, How much did you miss school within the last 12 months because of working on the farms?

OFTEN	1	☐
SELDOM	2	
NEVER	3	

5. In which season did you miss school most often so that you could help your parents/guardians with farm work?

RAINY SEASON	1
DRY SEASON	2

IV. PARTICIPATION ON HOUSEHOLD PRODUCTION

1. Some children do help their parents/guardians with domestic work like caring for younger children, cooking, and cleaning on normal school days. Do you also do the same?

YES	1	☐
NO	2	

2. If YES, on average how many hours in a day do you spend on domestic work?

Hour per day		

3. Does this work sometimes prevent you from going to school?

YES	1	
NO	2	☐

4. If YES, How much did you miss school within the last 12 months because of house chores?

OFTEN	1	
SELDOM	2	☐
NEVER	3	

5. In which season did you miss school most often so that you could help your parents/guardians with house chores?

RAINY SEASON	1	☐
DRY SEASON	2	

V. SUBJECTIVE ECONOMIC WELFARE

1. Taking everything into account, how satisfied are you in this household with the way the household lives these days? Choose one response.

Very dissatisfied	1
Dissatisfied	2
Satisfied	3

Thank you for your cooperation.

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Annex to statement
Name: Romanus Lucian Dimoso
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Completed Training and Supervision Plan

Name of the course	Department/ Institute	Year	ECTS (=28 hrs)
I. General part			
Techniques for Writing and Presenting a Scientific Paper	Wageningen Graduate School	2005	1.2
Quantitative Research Methodology	Mansholt Graduate School	2006	2.5
		Subtotal part I	**3.7**
II. Mansholt-specific part			
Mansholt Introduction course	Mansholt Graduate School	2005	1.5
Mansholt Multidisciplinary Seminar	Mansholt Graduate School	2008	1
Presentation 1 International Conference	12th Congress of the European Association of Agricultural Economists, Ghent. Belgium	2008	1
Presentation 2	PhD Day 2009. Mansholt Graduate School	2009	1
		Subtotal part II	**4.5**
III. Discipline-specific part			
Behavioural Economics	Mansholt Graduate School	2005	4
Advanced Econometrics	Mansholt Graduate School	2005	6
Public Economics	NAKE	2006	3
Development Economics	NAKE	2006	3
Natural Resources and Environmental Economics	NAKE	2007	6
Research Methodology	Mansholt Graduate School	2008	4
		Subtotal part III	**26**
		TOTAL	**34.2**

*One ECTS on average is equivalent to 28 hours of course work

SUMMARY

The rural South Pare highlands in Tanzania experience a deteriorating environmental situation. The causes of environmental degradation are population growth, deforestation, poor farming techniques, and weak forestry regulatory frameworks. Of particular importance is the disappearance of forests and woodlands. The consequences are declining amounts and reliability of rainfall, lower water levels and loss of biodiversity. Deterioration of environmental resources increases the costs of collecting environmental products, which in many respects have no feasible close substitutes. One of the major components of the increased costs is labour time allocated by household members to collecting environmental products and/or grazing activities. This reallocation of intra-household labour resources may have different effects on welfare for different members of a household. Degradation of the local environmental resource base is expected to adversely affect women and children more than men. Furthermore, labour time reallocation may interfere with labour allocated to other agricultural activities in the area. In addition, it could drain much of the time children allocate to schooling activities, which may have negative implications for their school attainment and the quality of their human capital in the long run. Lastly, intra-household labour resource reallocation may influence the subjective welfare and well-being of households.

This study presents an empirical analysis of these effects. The analysis is based on cross-sectional data collected in 2006/2007 from households in the Tanzania's rural South Pare highlands. The study was guided by four hypotheses each of which formed the basis of an empirical chapter of the thesis.

The first empirical chapter is **Chapter 3,** in which we investigated whether *the deteriorating environmental resources had an 'adverse impact' on intra-household labour allocation.* We applied the neo-classical model of an agricultural household. To analyse how variations in environmental degradation affect intra-household labour allocation, three types of areas were distinguished: severely-degraded, medium-degraded, and non-degraded environments. Since many individuals spent zero hours on some activities, we corrected for selection bias by using Heckman's two-step selection method. The results show that environmental products collection and/or grazing activities in South Pare were gender biased with husbands specializing in grazing while wives and children specialized in fetching water and fuel wood. Secondly, we found that environmental products collection and/or grazing time by the household members was, almost in all groups and in accordance with gender-biased activity, significantly influenced by the environmental conditions. Thirdly, we noticed that if a spouse or a schoolchild had participated in an intra-household activity, his/her time in the work had a significant impact on the time spent by the other spouse in that particular activity, especially in water and fuel wood fetching for household use.

In **Chapter 4**, we analysed whether e*nvironmental degradation led to lower agricultural production and household consumption* of home-produced meals prepared from staple food crops, namely, maize, beans, millet and paddy. Since the crop outputs weighed differently, we used the monetary value of their yields as a common scale. The amount of food consumed was expressed in calories per person, per day. The basis of the theoretical framework was a neo-classical model of agricultural household production. We

estimated the model with two-stage least squares (2SLS) to control for the endogeneity of production and consumption within households. The estimation results of the agricultural production equation show that agricultural output was significantly related to consumption of these crops, environmental degradation conditions, total cropped land, fertilizer application, ox-plough use and total extra-income accrued from other sources minus the monetary value of their own-domestic consumption. With regard to the home-produced meals, the results indicate that their consumption is significantly related to the agricultural output, environmental degradation, household income, and household size.

In the final analysis, both descriptive and regression results indicate that there are strong possibilities that environmental degradation is limiting the production and consumption potential in the area and that a limited adoption of agricultural modernization further aggravates this problem.

In **Chapter 5**, we examined whether the school attainment of children in rural primary schools, with respect to their gender, was inversely affected by deteriorating environmental resources. The basis of this analysis were the prior results showing that schoolchildren were involved in the work, supporting their households' livelihoods, including housework, farming, collecting scarce environmental products and/or grazing. This type of child labour frequently led to foregone schooling, which may have critical consequences for educational achievements.

Since the grade–to–age school attainment, our dependent variable, is an ordinal variable, which indicates a ranking of school attainment, we used ordered probit estimation techniques. The results show that the probability of educational attainment at primary school, was found to be significantly associated with age, age-squared, and the mother's secondary education. The formal employment status of the mother at government offices significantly, but differently, affected the probability of educational attainment of both schoolgirls and schoolboys separately, but not in the pooled estimates. The household ethnicity, i.e., belonging to the Sambaa tribe, significantly decreased the probability of schoolgirls to progress at primary school, as compared with other tribes. Interestingly, in the severely-degraded environment as compared with the non-degraded area, the probability that girls would progress at school decreased significantly. However, the environmental degradation situation neither had significant impact for schoolboys in their educational attainment nor for schoolgirls and schoolboys pooled together.

Our basic findings further show that there were other factors (like school crowdedness, illness, bad weather, poor school quality, and school absenteeism due to street vending) that affected the probability of school attainment for the schoolchildren apart from the environmental degradation situation. Reasons for this were twofold. Firstly, girls and boys spent, on average, the same number of hours per week in school activities across environmental conditions. Secondly, deteriorating resources like environmental products collection and/or grazing, work at home, and work on the farms, each contributed only marginally to total primary school late entry, negatively affecting the girls only.

In **Chapter 6,** we investigated whether *the household subjective economic welfare was inversely affected by deteriorating environmental resources.* The first objective of this section was to study the individual welfare function. We applied a lognormal welfare function of income to analyze the income evaluation question (IEQ). The average estimated values of the want parameter of the individual welfare function, denoting the log-income evaluated at 0.5 on the [0,1] welfare scale, were found to be 4.46 for husbands and 4.39 for

wives, corresponding with 86,487 and 80,640 Tanzanian Shillings, respectively. These amounts of income were evaluated as insufficient on average. The evaluated income was well above the official Government minimum wage in 2006/2007 of 75,340 Tanzanian Shillings per month, suggesting that individuals in South Pare needed an income well above the official monthly minimum wage to experience even an insufficient income.

The results of the extended model show that, for both husbands and a wives, the individual welfare parameter significantly increased with an increase in household income, use of scarce environmental products, namely, fuel wood and water, and household consumption of the survey crops. The want parameter for husbands alone also increased with education, while the want parameter for wives alone also increased with having an occupation. Taking the ceteris paribus condition, the results show that an increase in the use of these scarce environmental products would obviously lead to higher opportunity costs, which, in turn, would increase the want welfare parameter. This suggested that the individual would need higher income through the exponential of the want parameter to maintain the same welfare level.

The second objective of the Chapter 6 was to examine subjective well-being. The results of an ordered probit model showed that subjective well-being was negatively influenced by environmental degradation. That is, living in a medium-degraded area, as compared with a non-degraded environment, significantly decreased the husband's well-being. A wife perceived lower well-being if she happened to live in a severely-degraded place, while a schoolchild felt unhappy living in either a medium or a severely-degraded environment. The findings in Chapter 3 already described that environmental degradation influenced the burden of labour (thus affecting well-being) differently to each family member depending on the gender of a person.

Furthermore, household income had a significant positive influence on the husband's well-being, while the time he spent on domestic chores and the interaction of household size and income reduced his probability of well-being. The well-being of the wife was significantly non-linear in the effect of age, decreasing after the age of 60.5 years. The results further show that the well-being of a wife was also negatively associated with the time she spent on domestic chores and grazing, thus supporting the findings that women in the area associated many of their health problems with their heavy domestic responsibilities.

This study is instrumental in understanding the problems of sustainable development, poverty alleviation, environmental policy and the position of women. Policies designed to preserve the natural resource base (e.g., forestry projects) would be recommended in view of long-run benefits. Short-run strategies would include improving production technologies and persuading household members to grow drought-resistant crops. Lastly, policy makers need to devise overall strategies that would stimulate high economic growth rates in both the medium and long term.

The findings of this study may be strengthened by the availability of longitudinal data, to reveal a pattern of change in relation to time. This will need a longer period of research.

NEDERLANDSE SAMENVATTING

Het landelijk gebied van de South Pare Highlands in Tanzania is onderhevig aan een aanzienlijke verslechtering van het milieu. De oorzaken van deze achteruitgang zijn de bevolkingstoename, ontbossing, verouderde landbouwtechnieken en beperkte bosbouwregelgeving. De belangrijkste oorzaak is het verdwijnen van bossen en bosgebieden. De belangrijkste gevolgen zijn verminderde regenval met een onbetrouwbare frequentie, lagere waterstanden en verlies van biodiversiteit. Aantasting van natuurlijke hulpbronnen zorgt voor hogere kosten voor het verzamelen van water en brandhout en het laten grazen van het vee, omdat er geen substituten zijn. Een van de belangrijkste oorzaken van deze toegenomen kosten is een toename in de tijd die leden van een huishouden besteden aan deze activiteiten. De herverdeling van arbeidsmiddelen binnen een huishouden kan verschillende effecten hebben op het welzijn van de verschillende leden van een huishouden. Aantasting van lokale natuurlijke hulpbronnen zal naar verwachting een groter negatief effect hebben op vrouwen en kinderen dan op mannen. Verder kan de herverdeling van arbeidstijd de tijd beïnvloeden die is gereserveerd voor andere agrarische activiteiten in het gebied. Daarnaast kan de tijd die wordt besteed door kinderen aan onderwijs negatief worden beïnvloed, wat negatieve gevolgen kan hebben voor de voortgang op school en hun persoonlijke ontwikkeling op de lange termijn. Ten slotte, kan een herverdeling van arbeidsmiddelen binnen een huishouden invloed hebben op subjectieve welvaart en het welzijn van een huishouden.

Deze studie presenteert een empirische analyse van deze effecten welke gebaseerd is op cross-sectionele data verzameld in 2006/2007 bij huishoudens in het landelijk gebied van de South Pare Highlands in Tanzania. De studie is gebaseerd op vier hypothesen, waarbij iedere hypothese de basis vormt voor een empirisch hoofdstuk in dit proefschrift.

Het eerste empirische hoofdstuk is **Hoofdstuk 3,** waarin we onderzocht hebben of *de aantasting van natuurlijke hulpbronnen een ongunstig effect heeft gehad op de verdeling van arbeid binnen een huishouden.* We gebruiken het neo-klassieke model van een agrarisch huishouden. Om te analyseren hoe variaties in aantasting van het milieu van invloed zijn op de verdeling van arbeid binnen een huishouden, zijn drie typen gebieden onderscheidden: ernstig aangetaste gebieden, matig aangetaste gebieden en niet-aangetaste gebieden. Aangezien veel individuen geen tijd besteden aan bepaalde activiteiten hebben we een correctie aangebracht voor een selectie-effect door gebruik te maken van Heckman's two-step schattingsmethode. De resultaten laten zien dat het verzamelen van water en brandhout en het laten grazen van het vee in de South Pare Highlands verschillend was voor mannen en vrouwen, waarbij echtgenoten zich specialiseren in het laten grazen van het vee terwijl echtgenotes en kinderen gespecialiseerd zijn in het halen van water en brandhout. Ten tweede hebben we gevonden dat de tijd die leden van een huishouden aan deze activiteiten besteden in bijna alle groepen, en in overeenstemming met de specifieke taken voor mannen en vrouwen, significant beïnvloed werd door de condities van het milieu. Ten derde hebben we opgemerkt dat wanneer een partner of schoolgaand kind deelgenomen had aan een huishoudelijke activiteit, zijn of haar werktijd een significant effect had op de tijd die door de andere partner aan die specifieke activiteit besteed werd, in het bijzonder voor het halen van water en brandhout.

In **hoofdstuk 4** hebben we onderzocht of *aantasting van het milieu tot een lagere agrarische productie en huishoudelijke consumptie heeft geleid* van huisgemaakte maaltijden bereid met vezelrijke voedingsgewassen, voornamelijk maïs, bonen, gierst en rijst. Aangezien opbrengsten van voedselgewassen verschillend gemeten worden, hebben we de monetaire waarde van hun opbrengsten gebruikt als algemene schaal. De hoeveelheid geconsumeerde voeding is uitgedrukt in calorieën per persoon per dag. De basis voor het theoretische model is een neo-klassiek model van agrarische huishoudproductie. We hebben het model geschat met two-stage least squares (2SLS) om te kunnen controleren voor de endogeniteit van de productie en consumptie binnen een huishouden. De geschatte uitkomsten van de agrarische productiefunctie laten zien dat agrarische productie significant gerelateerd was aan de consumptie van deze gewassen, aantasting van het milieu, totale hoeveelheid gebruikte landbouwgrond, toepassing van meststoffen, gebruik van de ossenploeg en totale extra inkomen behaald uit andere bronnen verminderd met de monetaire waarde van hun eigen consumptie. Met betrekking tot de huisgemaakte maaltijden geven de resultaten aan dat hun consumptie significant gerelateerd is aan agrarische productie, aantasting van het milieu, huishoudinkomen en huishoudgrootte.

In de laatste analyse geven zowel de beschrijvende als de regressieresultaten weer dat het zeer waarschijnlijk is dat aantasting van het milieu de potentiële productie en consumptie in het gebied beperkt en dat in een beperkte mate moderniseren van de landbouw het probleem verder verergert.

In **hoofdstuk 5** hebben we onderzocht of de voortgang op school van kinderen op basisscholen in landelijke gebieden, met betrekking tot hun geslacht, negatief beïnvloed werd door de aantasting van natuurlijke hulpbronnen. De basis voor dit onderzoek waren eerdere resultaten die lieten zien dat schoolgaande kinderen betrokken waren bij werkzaamheden om in het levensonderhoud van hun gezin te voorzien, inclusief huishoudelijk werk, agrarische activiteiten, het verzamelen van water en brandhout en het laten grazen van het vee. Dit type kinderarbeid heeft vaak geleid tot absentie op school wat ernstige gevolgen kan hebben voor schoolprestaties.

Omdat de voortgang op school (op de juiste leeftijd het juiste lesniveau), onze afhankelijke variabele, een ordinale variabele is die de rangorde van schoolvoortgang aangeeft, hebben we een geordende probit schattingstechniek gebruikt. De resultaten tonen aan dat de kans om op de juiste leeftijd het juiste lesniveau te volgen op basisscholen significant samenhangt met leeftijd, gekwadrateerde leeftijd en het vervolgonderwijs van de moeder. Een officiële functie van de moeder bij een overheidsinstelling beïnvloedde significant, maar verschillend de kans op voortgang in het onderwijs voor zowel schoolgaande meisjes als jongens afzonderlijk, maar niet in de samengevoegde schattingen. De etniciteit van een huishouden, bijvoorbeeld behoren tot de Sambaa stam, verminderde significant de kans dat schoolgaande meisjes vooruitgang boekten op de basisschool, vergeleken met andere stammen. Opmerkelijk is dat in de ernstig aangetaste gebieden in vergelijking met de niet aangetaste gebieden, de kans dat meisjes vooruitgang boekten op school significant werd verminderd. Echter, de verslechterde milieusituatie had zowel op de voortgang op school van jongens als op beide groepen samen geen significante invloed.

Verder blijkt uit onze resultaten dat er afgezien van de verslechtering van het milieu andere factoren (zoals drukte op school, ziekte, slechte weersomstandigheden, lage onderwijskwaliteit en absentie op school door activiteiten in de verkoop op straat) waren die de mate van vooruitgang voor de schoolgaande kinderen bepaalden. De redenen

hiervoor waren tweeledig. Ten eerste besteedden meisjes en jongens gemiddeld evenveel uren per week aan scholing in de verschillende milieucondities. Ten tweede werden alleen de meisjes negatief beïnvloed door aantasting van bronnen voor activiteiten zoals het verzamelen van water en brandhout en het laten grazen van het vee, huishoudelijk werk, werk op het land. Deze aantasting droeg slechts marginaal bij aan het pas op late leeftijd naar de basisschool gaan.

In **hoofdstuk 6** hebben we onderzocht of de *subjectieve economische welvaart van een huishouden negatief beïnvloed werd door de aantasting van natuurlijke hulpbronnen.* De eerste doelstelling van dit hoofdstuk was het bestuderen van de welvaartsfunctie. We hebben een lognormale welvaartsfunctie van het inkomen toegepast om de inkomensevaluatievraag (IEQ) te analyseren. De gemiddelde geschatte waarden van de parameter voor de gewenste situatie van de individuele welvaartsfunctie, waarbij het log-inkomen bepaald was op 0,5 op een [0,1] welvaartsschaal, waren 4,46 voor echtgenoten en 4,39 voor echtgenotes, wat overeenkomt met respectievelijk 86.487 en 80.640 Tanzaniaanse Shillings. Deze inkomenshoogtes werden in het algemeen als ontoereikend beschouwd. Het geëvalueerde inkomen was ruim boven het officiële overheidsminimum inkomen in 2006/2007 van 75.340 Tanzaniaanse Shillings per maand, wat aangeeft dat individuen in de South Pare Highlands een inkomen nodig hebben dat ruim boven het officiële minimuminkomen per maand ligt om het inkomen vervolgens nog steeds als ontoereikend te ervaren.

Uit de resultaten van het model blijkt dat de parameter voor individuele welvaart voor zowel de echtgenoten als echtgenotes significant toenam bij een toename van het huishoudinkomen, het gebruik van brandhout en water en huishoudconsumptie van de verbouwde gewassen. De parameter voor de gewenste situatie voor alleen echtgenoten nam ook toe bij genoten onderwijs, terwijl de wensen parameter voor echtgenotes alleen ook toenam bij het hebben van werk. De ceteris paribus conditie in ogenschouw nemend tonen de resultaten aan dat een toename in het gebruik van water en brandhout logischerwijs leidt tot hogere opportuniteitskosten, die op hun beurt zorgen voor een verhoging van de parameter voor de gewenste situatie. Dit suggereert dat een individu een hoger inkomen nodig zou hebben door het exponentiële karakter van de parameter voor de gewenste situatie om hetzelfde welvaartsniveau te kunnen behouden.

De tweede doelstelling van hoofdstuk 6 was het bestuderen van het subjectieve welzijn. De resultaten van een geordend probit model toonden aan dat subjectief welzijn negatief beïnvloed wordt door aantasting van natuurlijke hulpbronnen. Dit betekent dat in een gebied dat matig is aangetast, vergeleken met een niet aangetast gebied, het welzijn van de echtgenoot significant werd verminderd. Een echtgenote ondervond een lager welzijn wanneer zij in een ernstig aangetast gebied woonde, terwijl een schoolgaand kind zich ongelukkig voelde wonend in een matig of ernstig aangetast gebied. De bevindingen in hoofdstuk 3 toonden reeds aan dat een verslechtering van het milieu de lasten van arbeid (dus van invloed op welzijn) voor elk gezinslid verschillend beïnvloedde afhankelijk van het geslacht van de persoon.

Huishoudinkomen had bovendien een significant positieve invloed op het welzijn van de echtgenoot, terwijl de tijd die hij besteedde aan huishoudelijke taken, de interactie tussen de gezinsgrootte en het inkomen zijn mate van welzijn verminderde. Het welzijn van de echtgenote hing significant niet-lineair samen met leeftijd en nam af na de leeftijd van 60,5 jaar. De resultaten tonen verder aan dat welzijn van een echtgenote ook negatief

samenhing met de tijd die zij besteedde aan huishoudelijke taken en het laten grazen van het vee, wat de resultaten ondersteunt die aangeven dat de vrouwen in het gebied veel van hun gezondheidsproblemen associeerden met hun zware huishoudelijke werkzaamheden.

Dit onderzoek is relevant voor het begrijpen van problemen met betrekking tot duurzame ontwikkeling, armoedebestrijding, milieubeleid en de positie van vrouwen. Beleid gericht op het behoud van natuurlijke hulpbronnen (zoals bosbouwprojecten) worden aanbevolen met het oog op lange-termijn voordelen. Korte-termijn strategieën zouden kunnen bestaan uit het verbeteren van de productietechnieken en het overtuigen van leden van een huishouden om droogteresistente gewassen te telen. Ten slotte zouden beleidsmakers strategieën moeten uitwerken die hogere economische groeicijfers stimuleren op de middellange en lange termijn.

Het is interessant om de bevindingen van dit onderzoek in vervolgonderzoek aan te vullen met longitudinale data om zo wellicht een patroon van verandering in relatie tot tijd te ontdekken.

ABOUT THE AUTHOR

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