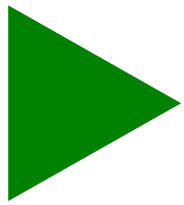
A qualitative and quantitative assessment of soil nutrient management in Tigray

H. Mulder

Working Paper
2002-07



Policies for Sustainable Land Management in the Ethiopian Highlands

IFPRI-WUR project *Policies for Sustainable Land management in the Ethiopian Highlands*

Land degradation problems--including soil nutrient depletion, soil erosion, deforestation and other concerns--are severe in the Ethiopian highlands. These problems are contributing to low and declining agricultural productivity, poverty and food insecurity. The proximate causes of these problems are relatively well known. Underlying these proximate causes are many more fundamental causes. These more fundamental causes are affected by many aspects of government policy. Assessing the impact of different causal factors and identifying effective policy strategies to improve land management is a critical research challenge that has not yet been solved. In part, this is due to the complexity of factors influencing the problem. “One-size-fits-all" policy or program approaches are unlikely to be broadly successful. There is thus a general need and desire for more effective targeting of policy strategies towards specific regions and groups, although this depends on improved information about the potential impacts of alternative strategies.

The long-term goal, immediate purpose and specific objectives of the project are as follows:

Long-Term Goal:
To contribute to improved land management in the Ethiopian highlands, in order to increase agricultural productivity, reduce poverty and ensure sustainable use of natural resources.

Immediate Purpose:
To help policy makers in Ethiopia identify and assess strategies, including technology development policies, to achieve that goal.

Specific Objectives:

- To identify the key factors influencing land management in the Ethiopian highlands and their implications for agricultural productivity, sustainability and poverty;
- To identify and assess policy, institutional and technological strategies to promote more productive, sustainable, and poverty reducing land management;
- To strengthen the capacity of collaborators in the Ethiopian highlands to develop and implement such strategies, based upon policy research; and
- To increase awareness of the underlying causes of land degradation problems in the Ethiopian highlands and promising strategies for solving the problems.

The research takes place in Tigray, Northern Ethiopia. The project started in January 2001 and will continue until December 2003.

The WUR component of the project is funded by the Dutch Ministry of Foreign Affairs, Cultural Cooperation, Education and Research Department, Research and Communication Division (WW132171), Wageningen University (RESPONSE programme) and the Netherlands Ministry of Agriculture, Nature Management and Fisheries (North-South Programme). Their support is gratefully acknowledged.

More information can be found at the project web site:

www.sls.wau.nl/oe/pimea

The Participants

The WUR component of the project is co-ordinated by the **Development Economics Group** of **Wageningen University**. Next to overall project management, the DEG is responsible for bio-economic modelling and backstopping of research activities.

For more information and ordering of working papers contact:

Dr. G. Kruseman
Tel : +31 (0) 317 484668
Fax: +31 (0) 317 484037
Gideon.Kruseman@wur.nl

The **Trade and Development Group** of the **Agricultural Economics Research Institute** (LEI) is responsible analysis of current and alternative agricultural activities, using the NUTMON methodology.

For more information:
G. Meijerink
Tel : +31 (0)70 3358243
Fax: +31 (0)70 3615624
Gerdien.Meijerink@wur.nl

Plant Research International (PRI) is responsible for analysis of potential activities, using TCGs, and the analysis of the dynamics of natural resources.

For more information:
Dr. H. Hengsdijk
Tel : +31 (0) 317 475913
Fax: +31 (0) 317 418094
Huib.hengsdijk@wur.nl

ALTERRA is responsible for the spatial aspects of sustainable land management and the scaling-up of biophysical processes, using the LISEM model.

For more information:
Dr. M.E. Mosugu
Tel : +31 (0)317 474648
Fax: +31 (0)317 419000
mary.mosugu@wur.nl

In Ethiopia the local partner is **Mekelle University**. MU is responsible for facilitation of PhD and other research conducted within the framework of the project.

For more information:
Dereje Aberra
Derejeaa@yahoo.com

The other project partner is the **International Food Policy Research Institute**. IFPRI is primarily responsible for the marketing analysis.

For more information:
Dr. J.Pender
j.pender@CGIAR.ORG

List of *Policies for Sustainable Land Management in the Ethiopian Highlands* working papers:

2002-01 Kruseman, G., J.Pender, G.Tesfay and B.Gebremedhin *Village stratification for policy analysis: multiple development domains in the Ethiopian Highlands.*

2002-02 Kinfe Abraha Weldemichael *Public and private labour investments and institutions for soil and water conservation in Tigray, Northern Ethiopia.*

2002-03 Boetkees, S. *Rural credit and soil and water conservation: a case study in tigray, Northern Ethiopia.*

2002-04 Kruseman, G., R.Ruben, G. Tesfay *Diversity and Development Domains in the Ethiopian Highlands*

2002-05 Meijerink, G.W. *Alternative cropping practices in Ethiopia: A literature review*

2002-06 Meijerink, G.W. *Rural livelihoods and soil conservation in Eastern Tigray; A Rapid Diagnostic Appraisal Report for Gobo Deguat and Teghane*

PIMEA WORKING PAPER 2002-05

A qualitative and quantitative assessment of soil nutrient management in Tigray

H. Mulder

Wageningen, May 2003

Abstract

The objectives for this research were to provide high quality quantitative and qualitative analyses on a selected number of households at two villages with different development potentials. Analyses were done on the factors of income and nutrient management and development and management opportunities were to be identified. The fieldwork for the research done at the kushet (village) Teghane, which has good market access and development potential and the kushet Gobo Deguat having poor market access and low development potential. Both sites are situated in Tigray, in the northern highlands of Ethiopia. To obtian a good insight on the farmers of Teghane and Gobo Deguat a Rapid Diagnostic Appraisal using participatory tools was done before the selection of the farmers. The NUTMON toolbox was used for further analyses, starting with data collection and surveying on income and nutrient management, of eighteen sample households over one year from February 2001 to February 2002. Conclusion were drawn from analyses on the results from the NUTMON toolbox. Opportunities for Teghane lie in the intensification of agricultural land because returns on external inputs were high and there were households that had the capital means to invest in improved technologies. Livestock is a high cost to many farmers in Teghane because of high energy demand. Reducing the number of especially large ruminants such as oxen, could be done by finding alternative ploughing technologies were less oxen are needed. Off-farm work was seen to be very important for the poorer households for food security and poverty alleviation. The off-farm work opportunities are slight for Teghane and improvements have to be made, it should be investigated if this is possible on short timespan. Opportunities for the households of Gobo Deguat are slight. Lack of infrastructure, poor market access and the little off-farm work opportunities are factors which are not very likely change in the near future. Because of unpredictable rainfalls, small plots and high costs of new technologies it is risky to invest large amounts of money. In the long run the best strategy for the area may be migration. The question is if there are enough migration opportunities and if policies in one way or another are able to facilitate this.

Table of Contents

List of Tables and Figures

ANNEX TABLES:

CHAPTER 1 Introduction

Land degradation, desertification and soil erosion are recurrent phenomena (Hurni, 1990) and are some of the most serious environmental problems in the Northern highlands of Ethiopia linked to a high fast growing population and poverty. A lot of pressure is therefore put on the natural resources in the region. The loss of productive land undermines the rural livelihoods and food security. Tigray is still one of the areas were food aid is essential for the survival of a large part of the Tigrinian rural population, especially concerning the Eastern and the Central zones but also some of the Southern zones (FAO/WFP, 2001 2002). Famines have occurred in the past and are still occurring today.

Land degradation reduces crop yields followed by an economic decline and social stress. It is influenced by different factors, physical as well as socio-economic. Research plays an important role in identifying these factors and in helping to formulate adequate policy to prevent further degradation and reduce the risk of famines. Opportunities should be identified to achieve more sustainable land management by observing and analysing the farming systems and farm management practices including factors influencing land degradation, crop yields and income. With this in mind and the factors mentioned earlier I formulated my objectives.

- to provide a high quality quantitative and qualitative analysis on the selected households using the NUTMON-toolbox
- to describe and analyse for the selected households, the importance of the following two aspects for the farm household system:
    a) income
    b) nutrient management
- to identify sustainable management opportunities in relation to those two factors
- to compare the two sites and the different types of households on the objectives 1-3

From the objectives I formulated my main research question as follows:

“What are the sustainable management opportunities at household level when compared to the factors of income and nutrient management, using the results from the NUTMON-toolbox?”

Sub-questions:

In order to answer the main research questions I formulated different sub-questions. The questions are formulated with both factors of income and nutrient management in mind:

- what is the time spent on different activities linked to nutrient management and

income, as an indication of their importance within the household?

- what kind of activities can be identified by the household to secure income and nutrient management in a sustainable way?
- what types of households can be distinguished within the selected households?
- what are the management opportunities when analysing the NUTMON data on these two indicators?

NUTMON helps in obtaining high quality data on small scale, household level. It provides quantitative outcomes of the input data and analysis and interpretations of these results are used in answering the research questions. The advantage of such a small scale analyses is that it is highly detailed; no information is lost by aggregation of large survey data.

A rapid diagnostic appraisal (RDA) was performed before starting the NUTMON data collecting. The RDA was set up together with ir. Gerdien Meijerink from the LEI. The RDA gave, in a relatively short period of time, a good insight into the two areas. The data inputting for NUTMON was done in between field visits. Running the model and interpreting and analyzing the results was the last phase of this research and was conducted in the Netherlands at the Wageningen University and Research Centre.

Outline

The research objectives and main research question are described in the first chapter. Chapter 2 gives a general description of the research setting. Chapter 3 describes the method and materials and the execution of the rapid diagnostic appraisal (RDA). The RDA was performed before the start of the NUTMON survey in order to obtain extra information on the research sites. Chapter 4 describes the materials and methods used for the NUTMON toolbox including field measurements, calculations and assumptions. In the chapters 5 and 6 is a presentation of the results of the NUTMON toolbox focussing on the income and nutrient management factors. Chapter 7 will be a comparative analysis on the two sites also ending with the final summary and conclusions. The last two chapters include the constraints and the discussion related to this thesis.

CHAPTER 2 Area Description

2.1 Setting

The state of Tigray lies in northern Ethiopia and shares common borders with Eritrea in the north, the State of Afar in the east, the State of Amhara in the south, and the Republic of the Sudan in the west. The state lies between the 12° and 15° latitude and 36°30" to 41°50" longitudes. The total area covers a little over 80 000 km^2 (almost twice the area of The Netherlands). Altitudes vary from 500m above sea level to over 3 000m in the highlands of Adwa. It has a cultivated area of 800 000 ha, farmed by around 775 000 households. Tigray contributes to around 5 percent of the national cereals and pulses production (FAO/WFP report, 2002).

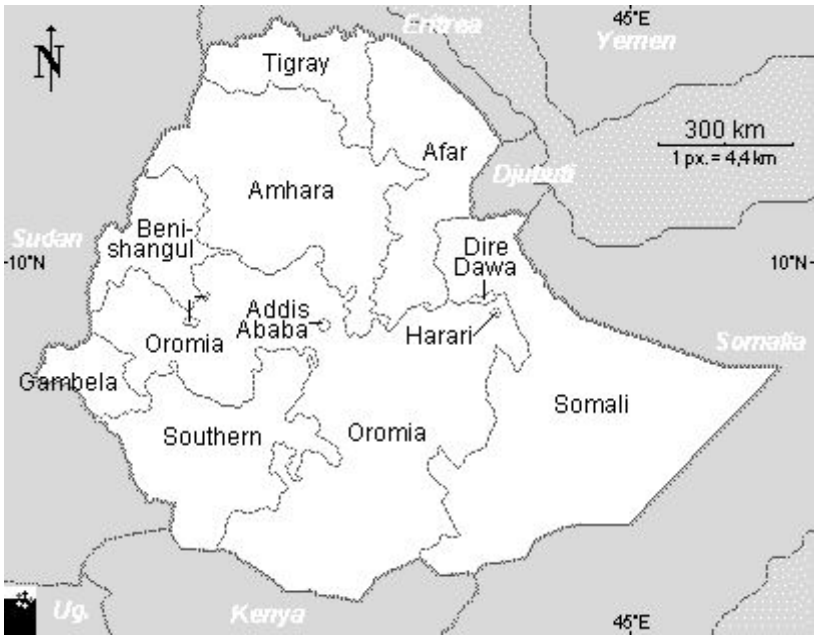


Figure 1: Map of Ethiopia

Tigray is divided up into four zones and 35 *woredas* (administrative districts). Each district is sub-divided into *tabia's* the lowest administrative units in the region. Each tabia again divided into *kushets* (villages). One *tabia* can consist up to eight *kushets.*

Three main farming systems can be identified in Tigray: the pastoral system, the mixed pastoral and cereal production system, and the mixed crop/livestock farming systems, the last system being the most common. Agricultural production is mostly rainfed as in the rest of Ethiopia. In Ethiopia only two percent of the total arable land is irrigated. Mixed farming is the most dominant type of farming system. It is based on traditional technology and animal traction.

Rainfall varies from about 200 mm in the North-eastern Highlands to over 1000 mm in the

Central Highlands of Tigray. The rainfall is seasonal and highly unpredictable. Most of the rainfall falls between June and September. The average maximum temperature lies around 28°C and the average minimum temperature around 12°C. These temperatures vary with altitude. In the highlands temperatures can drop under 5°C and night-frost may even occur. Due to these high differences in altitude, rainfall and temperature, different agro-climatic zones can be distinguished within short distance from each other.

Socio-economic situation Ethiopia

The total population of Ethiopia in July 2002 according to the Central Statistical Authority (CSA) was 67.673 million, with 5% of the population living in Tigray. Eighty five % comprised of rural population. From previous years the annual growth rate was estimated at around 2,64 % (CIA World Factbook, 2002). The economy of Ethiopia is highly dependent on agriculture. The agricultural sector constitutes of about 45 % of the GDP, followed by 43% from the service sector, and 12% from the industrial sector. The real GDP growth rate during the fiscal years 1998/1999 to 2001/2002 was between 5 and 8%. The economic reform programme, which started in 1992, has contributed to stability, with major but gradual devaluation of the birr and minimal inflationary consequences. The GDP growth rate averaged 5% a year between 1995/96 and 1999/2000 and was predicted to reach an average of 7% in 2001 and 2002. Owing to good crop harvest in 2000, grain prices followed a downward trend in the first half of 2001, enhancing access to food and improving food security (FAO/WFP report, 2001; 2002). Production is predominantly in the hands of small farmers working on individual smallholdings.

Local markets in Tigray are poorly developed. Most households produce crops for subsistence only. Livestock sales are much more common as a source of income. (Fitsum Hagos 1999). Use of hired labour is limited. The labour market is often underdeveloped.

Land degradation

Tigray is known for the areas of greatest land degradation concern in Ethiopia. The land degradation is mainly due to soil erosion and nutrient depletion and is so severe because of the combination of steep terrain and erratic rainfalls with human interference of deforesting large areas and overgrazing. (TE ALGEMEEN)

Degradation of the natural resources are reflected in lower crop yields, reduced grazing and browsing for livestock, less availability of fuel wood and a decrease of organic matter and water holding capacity of soils.

Even though quantitative soil loss measurements are rare in Tigray, indicators such as deterioration of cultivated land, lower yields and expanding gullies suggests the severe problems of soil erosion.

Land Reform

The land tenure system of Ethiopia changed a few times over the past decades. Before 1974 the land tenure system was very complex. There were many different tenure designations, of which the most common were the *rist (*communal ownership), private, church and state holding systems.

The 1974 revolution resulted in a series of policy measures aimed at expanding collective

state owned farm and non-farm enterprises and managing the economy by way of central planning. The 'Derg' (name given to the military government) proclaimed major land reforms, which turned all land into state property. The basic provision of the land reform proclamation of March 1975 nationalized all rural land, abolished tenancy, prohibited transfer use rights by sale, exchange, succession, mortgage and lease (except upon death and only to the wife, husband, or minor children of the deceased) and put peasants in charge of enforcement, putting away with landtenancy. No family was to own more than ten hectares of land. No able adult person was allowed to use hired labour to cultivate his holdings. Farmers were not allowed to engage in any off-farm activities themselves. The government wanted individuals to only have one occupation.

Farmers were expected to organize peasant associations, one for every 800 hectares, which would be headed by executive committees responsible for enforcement of the new order. Through these associations the farmers were able to access land. The farmers got users rights to land but there were restrictions such as the obligation to permanently live on the distributed farmland, the ability to farm continuously and to meet administrative dues and obligations. The peasant association made the decisions on further land distribution and management of natural resources. In most cases the associations made all resources like grazing area and forestland open access, leading to overexploitation.

After the collapse of the military government in 1991, the economy went from a centrally planned economy to market based one.. Despite the liberalisation process, the present Federal Democratic Republic of Ethiopia (FDRE), still follows the Derg regime on the land reform proclamation and no major land reform has taken place to date. The land is remains state property and the farmers are given users' right.

The population pressure, the increasing fragmentation of land and the frequent redistribution of plots among farmers are some of the current problems facing the rural farming system and can also be identified in the two selected villages.

Identified Sites

Teghane

Teghane is a *kushet* (village) part of the *tabia* of Gogoel Naele, which belongs to the *woreda* (district) of Atsbi Wenberta in the Eastern Province of Tigray. The total population in 2002 was 1742 consisting of 463 households of which 104 are landless, with an average of four persons per household. Of the 359 households having land, 44% is female headed.

Teghane has good market access, with the market being less than two kilometres away. In 1997 SAERT (Sustainable Agriculture and Environment Rehabilitation in Tigray) built a micro dam, clearly seen in the GIS map in Annex B(i) with the capacity of 70 ha of which now only 35 ha is used. It allows the farmers to grow a second crop in February. From the dam earth canals lead to different plots.

Gobo Deguat

Gobo Deguat is a *kushet* that lies in the *tabia* of Debre Bizen, which is part of the *woreda* of Hawzen. The total population in 2002 was 870 divided over 200 households of which sixteen are landless. The average family size is four. Of all households having land, 38% is female headed.

The *kushet* Gobo Deguat can be divided into three parts distinguished by soil type and altitude. There is a watershed area with its main characteristic being a large gully. The other two areas are the plateaus, which rise up at each side of the watershed. There is another watershed area at the other side of the main watershed, see Annex B(ii).

The main feature of the *kushet* Gobo Deguat is the gully running through the watershed. At some places the gully reaches a depth of almost 10 meters and a top width of 15 meters. Farmers explained that this gully has been formed over a period of 30 years, and was created due to a traditional method of soil and water conservation. This conservation method involves the diversion of excess water towards gullies, footpaths or pastureland. This concentration of runoff water led to deepening of the gully (Nyssen, 1998). This method of soil conservation can still be found on some of the fields in Gobo Deguat, but is not widely practised anymore.

To prevent further erosion of the gully, farmers plant eucalyptus trees trying to stabilise the soil. Check dams have been built, the first one in 2000, in attempting to stabilise the gully. It was part of a food-for-work (FFW) project by the local NGO REST (Relief Society of Tigray).

CHAPTER 3 Materials and Methods NUTMON

Introduction

The NUTMON toolbox was used to make a quantitative and qualitative analysis on household level. The outcomes of the toolbox are used for the economic as well as for the nutrient analysis. It includes a structured questionnaire, a database, and two simple statistical models: NUTCAL for calculation of nutrient flows and ECCAL for the calculation of economic indicators. Finally, a user-interface model is used to facilitate data entry and manipulation and extraction of data from the database to produce input for both models.

The data collected on the in- and outputs cover one cropping season. Monitoring would normally be done at regular intervals, e.g. per season or monthly, however, for this research it was chosen to monitor one whole cropping season in one monitoring session due to time constraints. From the RDA it was clear that most farmers start ploughing in the month of February. It was therefore decided to monitor the cropping season of February 2001 till February 2002, the season of the past year.

This chapter starts with the description of the farm household concept, followed by an explanation of all nutrient and economic in- and out flows within a farming system following the NUTMON toolbox methodology and approach. The last chapters describe materials and methods used for primary data collection of NUTMON, which include the selection of the farmers, followed by the actual survey. Additional information that was needed for the calculation of factors like soil losses, external inputs and livestock are described in annex-H. Because rainfall data has been lacking for Gobo Deguat a section is spent on how the problem was solved and what data were used as input in NUTMON.

Farm Household concept and nutrient flows

The nutrient flows and balances were only calculated for macronutrient N and are based on a set of five inflows, six outflows and six internal flows at farm level in NUTMON (Van Den Bosch et al., 1998). In table 1 the different nutrient flows are identified. Because of lack of data on the macronutrient Phosphorous (P) and Potassium (K) for certain crops and different soils, only Nitrogen (N) flows were analysed.

IN Flows		OUT Flows		Internal Flows	
IN1	Inorganic fertilisers and feeds	OUT1	Harvested products	FL1	Feeds
IN2a	Imported organic fertilisers and feeds	OUT2a	Exported crop residues and manure	FL2	Household waste
IN2b	Imported manure from external grazing	OUT2b	Excretion of manure outside the farm	FL3	Crop residue
IN3	Wet and dry Atmospheric deposition	OUT3a	Leaching from soils	FL4	Grazing of vegetation
IN4b	Symbiotic N-fixation	OUT3b	Leaching from Redistribution Units	FL5	Animal manure
IN4a	Non-symbiotic N-fixation	OUT4a	Gaseous losses from soil	FL6	Farm products to household
IN5	Irrigation and Flooding	OUT4b	Gaseous losses from Redistribution Units		
		OUT5	Runoff and erosion		
		OUT6	Human excreta		

Table 1 Nutrient flows at farm level in NUTMON (after Smaling et al., 1996)

The analyses are made on crop and livestock activities in terms of economic and nutrient flows and are determined at farm household level. The farm concept as described by NUTMON and in Van den Bosch et al (1998) was also used for this research.

The farm is split up into three compartments: primary production compartment, secondary production compartment and homestead. A schematisation of the (sub) compartments and the external nutrient flows can be found in annex-D(i).

The side boundaries of the farm coincide with the physical boundaries of the farm. The upper boundary of the farm is the atmosphere soil or the atmosphere plant interface and the lower boundary is thirty centimetres below soil surface, which is the layer from which plants retrieve most of the required nutrients. Only flows that flow in, out or between the (sub) compartments or at farm level are considered in the analysis.

Economic performance in NUTMON

For determining the economic performance of a farm household, NUTMON uses the ECCAL model. A schematisation of the economic flows is found in annex-D(ii). The results produced by ECCAL can basically be divided into two groups; (1) farm household characteristics and (2) performance indicators at farm and activity level.

For the first group different household characteristics such as consumer units and labour units, but also value of land, livestock and equipment were quantified and recorded. A complete list of all performance indicators assessed and the calculation method by ECCAL used for this study can be found in annex-E.

For the second group, cash flow measures and income and profitability measures are calculated. At farm as well as activity level, the cash flow and economic performance are relevant to farm household decisions concerning soil nutrient management. Values are

given to inflows of organic and mineral fertilisers (IN1 and IN2) and outflows of harvested products, crop residues and manures being sold (OUT1and OUT2). These flows are directly linked to farm nutrient management decisions.

At activity level economic gross margins and cash flows per unit area for the primary and secondary production compartments are calculated. At household level the economic performance is measured as net farm income (NFI) and family earnings (Van den Bosch et al 1998; de Jager et al. 1998). The net farm income measures the reward to the farm family for its labour and management and the return to all the capital investments in the farm including borrowed land. The total income available to the farm family is calculated as the total family earnings which includes the net farm income plus any other household income. At farm level a number of more specific performance indicators are calculated for the sum of the primary and secondary production compartments as well as the returns to invested capital family labour and land. The cash flow at farm level is expressed as the farm net cash flow (Van den Bosch, 1998).

Prices

For the financial analysis in NUTMON unit prices of crops, crop residues and animal products are recorded and were collected during the monitoring phase. The exchange rate in 2001/2002 was US$1= 8,54 birr.

When real prices could not be recorded, because for instance a transaction in kind was involved, inputted values were estimated on basis of opportunity costs and benefits. In general farm gate prices are used. Input and output markets are considered external.

For the calculation of gross margins, gross value, returns and variable costs, values for different assets had to be determined. However some assets are rarely bought or sold which makes estimating their value complicated. In the case of Gobo Deguat, which is situated at such a great distance from the nearest market, using farm gate prices would not be realistic, and therefore shadow prices were estimated.

Shadow prices are the opportunity costs of the resources used and reflect their relative scarcity (Upton, 1996). A shadow price approximates better the true opportunity cost or marginal valuation of a product or resource or service. Shadow prices of crops, livestock and equipment are a lot higher than the farm gate prices because not only are farmers in Gobo Deguat price takers, but they lose two days walking to the market and back home. After discussion with my supervisors and using their experience, I approximated the shadow price with two and a half times the farm gate price. One of the constraints for this study was that farm gate prices recorded in Gobo Deguat were subsidised prices paid for transactions with government institutions or NGO's. All the prices used in this research for Gobo Deguat and Teghane are found in annex-F and annex-G. For the prices of straw I took the average prices farmers paid for one headload. Most transactions of straw, however, were in kind and were among the farmers themselves.

For Teghane I used farm gate prices for the value of the crops, livestock and equipment. The market is very nearby and shadow prices are expected not to differ much from real market prices.

The labour shadow price in Gobo Deguat is much lower than the normal labour wage. The opportunity cost of labour is very low because there are not many other labour opportunities available since Gobo Deguat is isolated from large towns and markets. The market price for labour in 2001/2002 was around eight to ten birr an hour, for Gobo

Deguat it should be a lot lower than the real wage rate and a shadow price 2 birr per hour was used as input for the model.

Interest rate

For the interest rate I went to the Bureau of Agricultural and the NGO REST and asked the interest rate they charged for credits. They charge an interest rate of 12,5% per year, which I used as interest rate for NUTMON.

Nutrient management in NUTMON

The model NUTCAL is used for the quantification of nutrient flows and can be used on activity as well as on farm level. All external flows shown in annex-D(i) are considered by NUTCAL but also internal flows not shown in annex are considered.

For the quantification of flows three methods are used. The first method is asking the farmer through structured interviews, the second method is the use of transfer functions and the third is by using sub-models and assumptions.

The first method is based on questionnaires and determines the flows (see table 1) IN1, IN2, OUT1, OUT2, FL2, FL 3, FL5 and FL6. All flows are quantified. Local units are converted to SI-units. The total N is calculated by using the nutrient contents of the carrier (crop products, animal products, soil etc.).

The second method used in quantifying flows is with help of transfer functions. They are used to estimate flow quantities for which the information cannot be given by the farmer or obtained by simple measurements. These are called the “hard to quantify” flows and consist of consider the inflows of wet and dry deposition and N-fixation and for the outflows, leaching, gaseous losses and erosion.

The transfer functions are simple relations that explain difficult-to-quantify variables, as a function of easily obtainable parameters. The transfer functions used in the model are found in the describing literature on the NUTMON toolbox. The transfer functions are all part of smaller models within NUTMON and use certain default options in their calculations. A complete list of the default options used can be found in annex-J.

Method three is the use of sub-models and assumptions that are used in NUTCAL. These include assumptions made in the flows of external grazing (IN2c), symbiotic N-fixation (IN4a), sedimentation (IN5) and the actual feed consumption of the animals (FL 1a, 2b, 3b and 4). For the assumptions made in these flows reference can be made to van den Bosch et al. (1998).

Outcomes data types, partial nutrient balance and full nutrient balance

For the analysis of the nutrient management nutrient balances are calculated. The nutrient balances consist of a mixture of primary data, estimates and assumptions. Two nutrient balances are defined to make the distinction between primary data on the one hand and the estimates and assumption on the other.

The partial balance is made up of primary data only and is defined as IN1+IN2-OUT1. IN1

and IN2 represent the amount of nutrients into the farming system by way of mineral and organic fertilisers and OUT1 reflects the amount of nutrients in the farm products that leave the farm. The full balance is defined as (IN1-IN4)-(OUT1-OUT6) and is a combination of a partial balance and the hard to quantify flows with OUT6 six reflecting the home consumed farm products.

Selection of the farmers

General Selection Criteria

In each site eight farmers were to be selected based on two criteria (i) they had to represent a cross section of the community and (ii) half of them had to be actively practicing soil and water conservation management and the other half less actively or not.

In the following chapters these farmers are divided into the 'Experimental Farmer' (EF) and the 'Conventional Farmer' (CF) the first one being active and the second being less active group in Soil and water conservation practices. In each group of farmers selected there is one female headed household present.

The criterion of active and non-active farmers was selected so that the two groups could be compared to each other on basis of farm (nutrient) management and income. The selection was not made by the research team, but by key informants selected earlier during the RDA. These key informants were thought knowledgeable by the community people on the area and the households situated there. The terms conventional and experimental (active vs. non-active) farmers were explained to the key informant and he was asked to classify the households into these two groups.

The interpretation of the terms by these informants turned out to be different to that of the researcher team. In Teghane the key informants seemed to have made a selection on wealth or on status in the kushet and in Gobo Deguat it has not become clear on what basis the farmers were selected.

Household selection Teghane

It was decided to select households from the sub-*kushet* called 'Teghane' (see section *history*) because it was comparable to the *kushet* Gobo Deguat in the number of household and total area. The actual selection was made by the key informant, in this case the kushet administrator. The selected households, represented by the household heads, were divided into two groups of around ten people each, one group being the active farmers and one being the non-active farmers in Soil and water conservation.

At a meeting between the researcher, kushet administrator and interested farmers, the aims of the research and amount of time required from the farmers were explained to the farmers by a facilitator. In the end the farmers were asked to choose within each group, among themselves, four farmers who were willing to participate in the research. In this way the eight households were selected, four experimental (EF) en four conventional (CF) of which all but one were male headed.

The households were given identification codes starting with TG followed by a two digit number of 01 to 08. When visiting TG07 a problem occurred during the first interview. The female head of the household explained that she herself had not owned any land during the monitoring period, it was therefore not possible to include her in this research

and it was decided to select another female-headed household together with the kushet and vice-kushet administrator.

Household selection Gobo Deguat

The first selection of the different households was made with help of the list the *kushetadministrator* of Gobo Deguat had set up during the RDA. This selection of farmers (which were more than eight) was reviewed by the vice-kushet administrator and the tabia administrator, and some names where changed or added. A meeting was planned with all of the farmers present from the selection made by the committee.

With the meeting, the first day of the NUTMON surveying started and was used to explain the objectives of the research, what was expected of the farmers, the time span and the duration of each interview. In the end the farmers were asked if they were willing to participate. All the farmers were willing to participate and a selection had to be made by adding an extra criterion: the participation of the household in the IFPRI survey that was done in the area the previous year. The reason to do this was that there would be additional information available on the households who participated in the IFPRI survey, may be of later use to get a better understanding of the households and farming systems.

The eight farmers who were selected initially consisted all of older farmers. One of the criteria however was that it would be a cross section of the community and therefore a younger household was added to make nine. After the selection was made, five of the nine households were situated on the top of the plateau. Ideally an equal selection would have been made over the two watershed areas and the plateau also because of the apparent erosion in the watershed areas. The village committee was asked to select two more households which would be situated in the watershed, making it eleven.

From these households, one household did not have any crop production during the monitoring period and could not be taken up in the research. This only became clear during the first interview with the household head. Thus a selection of ten farmers was realised in the end.

The codes that were used for the households of Gobo Deguat is GD followed by a two digit number of 01 to 11 with exception of number 08, which was the household that did not take part in the research.

Inventory and Monitoring

NUTMON provides structured questionnaires, which collect a mixture of biophysical and economic data and relate to nutrient and cash flows, as well as characteristics of the households. The interviews are with one or more members of the farm household. The interviews were done in three visits spread over five days for each site. The questionnaires consist of two major sections: (i) Farm inventory, identifying the major features of the farm and serving as a framework for the monitoring phase; (ii) monitoring, identifying and quantifying the flows to all farm units; all relevant nutrient and economic flows are traced, including their sources and destinations

Information group	Type of information
Farm inventory	
General farm data	Geographical situation, land ownership etc.

Demographic structure of the household	Identification of all persons at the farm, sex age and occupation
Primary production compartments	Identification of parcels and parcel size and of the fields and crops present at the time of monitoring
Secondary production compartments	Sketch of parcels and farm infrastructure
Sketch of the farm	Identification of garbage heaps, compost pits, dunghills and kraals
Other compartments	Identification of implements present on farm; number and age
Input and output monitoring	
Input in secondary production compartments	Quantity and source of fertilisers, seeds, manure, crop residue, feeds, pesticides, labour, traction etc.
Output primary production compartments	Quantity and source of fodder, concentrates, veterinary services, labour etc
Output secondary production compartments	Quantity and destination of milk, eggs, hides skins, hiring out of animals, traction
Average confinement of the animals	Confinement to fields, pastures, fallows, farm yards, kraals and outside the farm
Redistribution of manure and household waste	Quantity and destination of reused manure and household waste
Herd growth	Number of animals born, purchased, gifts, consumed, died
Inputs and outputs food stock	Bookkeeping of staple foods in stock
Family labour	For each person: no. Of days spent on crops, livestock, general farm, household, off-farm activities
Off-farm income	Estimated off-farm income and amount invested in farm activities

Table 2 Main information categories included in the questionnaires (Van den Bosch et al., 1998)

Table 2 gives an overview on information categories discussed in the interviews. Only one or two topics were discussed with the farmer at each interview. The interviews would normally take around two hours each visit but could take longer or shorter depending on the time available of the farmer. If interviews had to take more time, because it was the last day, or the last interview, the survey questions would often be split up between household members. For example questions on various activities were, if possible, asked to individual household members because different household members have different tasks.

Another part linked to the inventory and monitoring surveys is the additional information, which cannot be given by the farmer but has to be measured, weighed or chemically analysed in a laboratory. This was done after the household interviews and in the annex-H a full description on the additional data is given.

Inventory

The inventory part started with a sketch of the farm by the farmer in which the household head drew all his or her plots and the crops grown during monitoring season and indicated which were owned or share cropped in or out. Then the Farm Section Units (FSU)[1] and the Primary Production Units (PPU)[2] were identified and indicated on the map.

A walk to all plots was included in the first visit. The map drawn beforehand by the

[1] FSU as defined in NUTMON is a continuous field within a farm which is assumed to have homogeneous soil properties, slope, a flooding regime and land tenure. These features are expected not to change in the near future (NUTMON manual 2000)

[2] A PPU is a crop activity consisting of one or various crops grown in one field. PPU is an activity within the farm, taking place over a specific period of time, and on a specific FSU (NUTMON manual 2000)

household head was taken along and FSUs were checked and if needed changes were made. The farmer was asked about the soil properties of each plot including the local soil name, depth and the description on the fertility of the soil. Other information gathered on the household was the demographic structure of the household, dependency on off-farm income and ownership of implements and machinery. Some topics were approached differently than indicated by NUTMON.

For the percentages on the importance of off-farm income the same participatory tool was used as in the RDA and the farmers were already familiar with it. The farmer got ten stones, which represented his total income, he or she then had to divide the ten stones into off-farm and on-farm income. Off-farm income included all work done off-farm, including food for work (FFW), cash or kind received.

For the calculation of economic indicators such as the farm level return to capital and to labour, the value of the owned land had to be known. As the system of land redistribution is very complex and the land is state owned, farmers had no idea what the value could be given to their land. I chose to use the net present value (NPV) of the opportunity cost of the owned farmland. With the NPV it is possible to define the value of any capital asset, in this case the value of land. The NPV is the discounted, present value of expected benefits (Upton, 1996).

The opportunity cost is measured as the benefits that result from the next best alternative use of the same resources that were rejected in favour of the one accepted, in the case of farmland owned by the farmer, the next best alternative would be to share crop out the farmland. The direct profit from sharecropping out the land is the profit coming from sale of half of the yield.

The opportunity cost of land is calculated by taking half of the average yield of the main cereal crop at each site and multiplying this by the unit price of the crop. Because land value is expected to be much higher in Teghane because of the relatively favourable conditions, the opportunity costs are multiplied with a factor of two and a half. From the opportunity costs the NPV was calculated for a period of 25 years and at a discount rate of 12,5% which is the interest rate charged by REST and the Bureau of Agriculture.

The unit prices given are average market prices indicated by the farmers. The average yield also comes from data collected for this research. The table 3 shows the opportunity costs and the Net Present Value (NPV).

Crop	Site	Total area (ha)	1/2 yield (kg ha^{-1})	Unit price (birr kg^{-1})	Opportunity cost (birr ha^{-1} yr^{-1})	NPV (birr ha^{-1})	Discount rate
Barley Rainfed	Teghane	2,83	1 038	1,70	4 412	37 590	12,5%
Barley Irrigated	Teghane	1,19	1 412	1,70	5 999	51 115	12,5%
Hanfest	Gobo Deguat	1,11	675	2,00	1 350	11 503	12,5%

Table 3 NPV of Land for Teghane and Gobo Deguat

The most common crop cultivated at each site is taken as the crop from which the opportunity cost is calculated. Barley takes the up largest part of the cultivated rainfed and irrigated area of Teghane. *Hanfest* is the main crop grown in Gobo Deguat and is mixture

of barley and wheat. In NUTMON *Hanfest* will be identified as a unique crop species, because it can be expected that the crops sown together interact with each other so much, that they are to be treated as one.

The calculation of the opportunity cost gives a yearly land rent of Teghane 4 412 birr for rainfed barley and 5 999 birr for Irrigated Barley, in Gobo Deguat this is calculated for Hanfest and is 1 350 birr per year. The NPV of land for Teghane is 37 590 birr ha^{-1} for rainfed and for irrigated land a value of a little more than 51 115 birr ha^{-1} is calculated. The value of land for Gobo Deguat comes to 11 503 birr ha^{-1}. These values were used as input data for calculations in NUTMON. In taking this land value, the assumption is made that all land has the same productive value and that the best alternative option is to share crop out land.

Monitoring

The monitoring data were collected for the period of February 2001 up to February 2002 with use of surveys. One or two household members were interviewed on nutrient and economic flows going in and out of the farm. It was decided not to let the farmers draw the flows, because they were very uncomfortable with paper and pen. The concept of the nutrient and economic flows in and out of the farm was explained to the farmers before each interview to be certain that it was well understood. The farmer was free to ask questions before and during the interview if things were unclear.

The monitoring started with recording for each crop the quantity and source of the inputs (fertilisers, seeds, manure, labour, traction etc.) and outputs (harvested products, crop residues etc). The same was done for the inputs (fodder, concentrates, veterinary services, labour etc.) and outputs (milk, eggs, traction etc) of the livestock (or secondary) production units (SPU)[3]. For farmers some of the questions which related to a year before were quite difficult, often data had to be cross checked with partners or other family members. Recycled nutrients are monitored by determining the quantities and destinations of manure and household waste and by the location of the confinement of the animals.

Labour inputs are recorded per person per activity. The activities are split up in the model into crop activities, livestock activities, general farm activities, household activities and off-farm activities. Of each of these activities cash flows are recorded.

Climate data Gobo Deguat

For the hard to quantify flows annual rainfall data is needed. Rainfall data of the monitoring period in Teghane is available from the World Vision office situated in Atsbi.

For Gobo Deguat rainfall data was lacking. The nearest meteorological station was at Hawzen, 28 km from Gobo Deguat. The data from Hawzen only covered seventeen years from 1972 till 1997. Rainfall Measuring instruments have been placed in Gobo Deguat only since May 2002. In Annex I the average rainfall per months is shown over the seventeen years. The figures are all round off to the nearest whole number. To get an idea on the rainfall situation of Gobo Deguat, I asked the sample farmers of Gobo Deguat to rank the rainfall from February 2001 till June 2002. For each month the farmer got ten

[3] FSU is a group of animal of the same breed/species, managed by the farmer as a single group in terms of feeding, care and herding/confinement (NUTMON manual 2000)

stones, the amount of stones indicating the amount of rainfall. Other household members or neighbouring farmers were joining the discussion on the rainfall ranking. From the six farmers who were asked there came a total of five observations because some sample farmers had discussed with each other.

The ranking obtained from the farmers combined with the rainfall data available from Hawzen and the rainfall data collected since May 2002 for Gobo Deguat, was used to estimate the monthly and annual rainfall in the area. The results can be seen in annex-I showing the ranking given by the farmers converted into percentages which then were multiplied by the average total rainfall.

CHAPTER 4 NUTMON Teghane

Introduction

This chapter describes the results obtained from the NUTMON toolbox for the *kushet* Teghane. This chapter will start with a general overview of all eight farms followed by a nutrient analysis based on N-values only.

It is important to realise that for the calculations assumptions have been made to complement missing data. Data that could not be collected in the field have been estimated from literature and include nutrient compositions of certain crops, soil characteristics described in the chapter materials and methods of this thesis and annex-H.

Farm system analysis Teghane

General Farm Characteristics

In Table 4 it can be seen that the average household comprises of seven persons, consisting of almost four labour units. The smaller families are often the younger families. The average area cultivated is 0,46 ha. The average value of the implements is 244 birr per farm. The most common implements are the animal drawn plough, the sickle and the axe. The most capital intensive implement is the *kareta*, which is an oil drum cut length wise in half and used as saddle bags for transportation of for example stones or salt.

The sample farm TG07, is female headed and does not own any implements. She borrows implements in exchange for labour or crop outputs. She also is the only farmer share cropping her land out. There are a few reasons why she share crops out, one of them is that she does not have access to a lot of family labour. Her children are still young and go to school. After school they herd the little livestock they have. Labour is not the only constraint, religion and cultural taboo forbid women to plough.

	Farm code Teghane									
	01	02	03	04	05	06	07	08	mean	stdev
Class	EF	EF	EF	EF	CF	CF	CF	CF		
Number of household members	9	8	10	7	8	4	5	6	7	2
Labour unit	4,53	4,43	5,88	2,95	3,13	1,65	2,96	3,13	3,58	1,22
Consumer unit	7,1	6,15	7,9	5,25	6,1	2,95	4,55	4,65	5,58	1,47
Total area (ha)	0,66	0,9	2,42	0,78	0,62	0,41	0,17	1,09	0,88	0,64
Total area owned (ha)	0,66	0,9	0,85	0,78	0,62	0,41	0,31	0,75	0,66	0,19
Total area share cropped in (ha)	0	0	1,57	0	0	0	0	0,34	0,24	0,52
Total area share cropped out (ha)	0	0	0	0	0	0	0,13	0	0,02	0,04
Average area cultivated (ha)	0,37	0,45	1,35	0,36	0,30	0,22	0,10	0,56	0,46	0,36
Total value of equipment (birr)	385	334	388	171	131	247	0	292	244	136
Average value of livestock (birr)	5 542	2 462	7 337	3 391	1 085	1 528	1 108	2 885	3167	2 233
Total value of land owned (birr ha^{-1})	25 910	36 082	32 813	34 518	24 162	16 793	13 838	30 375	26 811	8 199
Total capital (birr)	31 837	38 877	40 538	38 080	25 378	18 569	14 946	33 552	30 222	9 632
Number of FSUS	4	7	8	8	3	5	4	5	6	2
Number of crop types	2	5	4	8	6	3	2	5	4	2
Number of PPU	8	17	19	21	10	10	7	18	14	5
Number of TLU	7,71	3,59	9,32	4,47	1,56	2,22	1,37	3,83	4,26	2,69

NB Abbreviations EF and CF stand for respectively ‘Experimental Farmer’ and ‘Conventional Farmer’

Table 4 Basic Farm Characteristics Teghane

In table 5 the eight households of Teghane are split up into the 'experimental' and 'conventional' farmers. The experimental household consists of nine household members on average and the conventional household of six members, which is again reflected in the number of labour and consumer units of the two household types. Larger differences are seen between the total areas cultivated and total capital owned. The experimental farmer cultivates an average area of 0,63 hectares and has a total capital value of 5,8 thousand birr, both are more than double the amounts of the conventional household that only cultivates an average of 0,30 hectares and has a capital value of 2,7 thousand birr. Going back to the wealth ranking done in the RDA, the factors of land, livestock and labour defined the wealth of a household. Taking these indicators identified in the wealth ranking by the farmers, the experimental farmer would be classified as *rich household* and the conventional as belonging to the *average household*.

	EF		CF	
	mean	stdev	mean	stdev
Number of household members	9	1	6	2
Labour unit	4	1	3	1
Consumer unit	7	1	5	1
Total area (ha)	1,19	0,83	0,57	0,39
Total area owned (ha)	0,80	0,10	0,52	0,20
Total area share cropped in (ha)	0,39	0,79	0,09	0,17
Total area share cropped out (ha)	0,00	0,00	0,03	0,07
Average area cultivated (ha)	0,63	0,48	0,30	0,19
Total value of equipment (birr)	320	102	168	131
Total value of livestock (birr)	4 683	2 190	1 652	847
Total value of land owned (birr)	32 331	4 484	21 292	7451
Total capital (birr)	5 797	1 593	2 680	1 085
Number of fsus	7	2	4	1
Number of ppus	16	6	11	5
Number of tlus	6	3	2	1

Table 5 Basic farm characteristics per Farmer Type Teghane

Cultivated Crops and yields

Indicated in table 6 are the yields of the cereals and pulses cultivated by the sample farmers. The yields are taken over the average outputs of each farm and are thus different from the averages over the yields per plot. There are large variations in the yields obtained by each farmer but also between yield outputs of the different plots of the same farmer.

The average yields over the season of 2001 in Tigray for barley were 840 kilograms per hectare per year, for wheat 970 kilograms per hectare per year (FAO/WFP report, 2002) and for pulses 892 kilograms per hectare per year (CSA 1997a in Woldehanna, 2000). All farmers except for TG06 had cereal yields higher than the averages of Tigray.

	Average yields cereals and pulses (kg $ha^{-1}yr^{-1}$)								Average yield (kg ha^{-1})	Stdev
	TG01	TG02	TG03	TG04	TG05	TG06	TG07	TG08		
Class	EF	EF	EF	EF	CF	CF	CF	CF		
Barley	1 809	4 058	2 088	2 641	1 180	337		1 316	1 918	1 194
Barley irrigated	1 579	1 051	2199	4 657		3 999	3 944	1 250	2 668	1 494
Black wheat		1 379	1 150			1 034		347	978	444
Faba bean	667	3 182	3 040		541			1 778	1 841	1 256
Field pea					2 222			778	1 500	1 021
Flax					640				640	
Wheat		5 556	2 422	1 118	2 667			790	2 511	1 884
Wheat irrigated				3 160					3 160	

Table 6 Average Yields Teghane

Nutrient balance

Table 7 show positive N-balances for all sample farms at an average of 100 kilograms nitrogen per hectare per year. The partial N-balance is positive as well consisting of the nutrient flows coming from direct farm inputs and product outputs excluding the hard to quantify flows. The N-balance indicates that, at farm level, the farmers imported more into the system than was exported from the yield and sale products. The total and the partial N-balance are positively correlated to the input of organic fertiliser and negatively correlated to harvested product. The organic N input comes from the compost pit and from dung being collected during the day from the grazing areas, these two taken together give the high N-inflow through organic input (IN 2).

	Farm Code TG									
	01	02	03	04	05	06	07	08	Mean	Stdev
Class	EF	EF	EF	EF	CF	CF	CF	CF		
Total area (ha)	0,66	0,9	2,42	0,78	0,62	0,41	0,17	1,09	0,88	0,68
N-balance (kg ha^{-1} yr^{-1})	200	30	29	125	72	94	194	58	100	68
Partial N-balance (kg ha^{-1} yr^{-1})	261	88	126	188	108	130	305	104	164	80
Inflow N-mineral fert (kg $ha^{-1}yr^{-1}$)	4	17	8	26	39	9	38	4	18	15
Inflow N-organic fert (kg $ha^{-1}yr^{-1}$)	486	172	222	285	119	212	507	177	272	146
Outflow N-products (kg $ha^{-1}yr^{-1}$)	-38	-13	-7	-5	-2	-8	-29	-5	-14	13
Outflow N-organic (kg $ha^{-1}yr^{-1}$)	-190	-88	-97	-119	-47	-82	-211	-71	-113	58
Outflow N-erosion (kg ha^{-1} yr^{-1})	-21	-31	-87	-37	-16	-26	-32	-36	-36	22
Erosion (ton $ha^{-1}yr^{-1}$)	7,7	10,7	12,7	19,4	7,9	8,0	10,4	14,0	11,4	4,0

Table 7 N-flows and erosion rate at farm level for Teghane

It should be remarked that irrigation water has not been taken up into the leaching formula of the model due to lack of information on quantities. If it would have been included N outflow through leaching (OUT 3) would have been higher and the total N-balance therefore lower.

The amount of soil loss is positively correlated to the total area, the larger the cultivated area the higher the soil loss per hectare. Average soil loss taken over all sample farms is 11 tons per hectare per year. This seems low compared to other soil erosion rates found in literature for Tigray. According to the Hunting report (1975) the average rate of erosion in the central highlands of Tigray, the most densely populated area, was measures to be above 17 metric tons per hectare per year. Other studies in the 1980's found even higher erosion rates of more than 80 tons per hectare per year (REST 1989a, 1989b, Tekeste and Smith, 1989; in Hagos 1999). The Maydollo watershed was estimated at an average of 17 tons per hectare per year and is considered as representative for the central plateau area (1 500 – 2 000m elevation) (Esser 2002). Hurni (1987) has estimated the average rates of soil loss for cultivated land at an average of 42 tons per hectare per year. There are thus large variations in the estimates of erosion rates. But 11 tons per hectare, even though lower than estimated erosion rates, is still high and it is more than fifteen times higher than the soil formation rate.

	EF (n=4)		CF (n=4)	
	Mean	Stdev	Mean	Stdev
N-Balance (kg ha^{-1} yr^{-1})	96	71	104	53
Partial N-Balance (kg ha^{-1} yr^{-1})	165	66	162	83
Inflow N-mineral fertiliser (kg $ha^{-1}yr^{-1}$)	14	9	22	16
Inflow N-organic fertiliser (kg $ha^{=1}$ yr^{-1})	291	119	254	150
Outflow N-products (kg $ha^{-1}yr^{-1}$)	-16	13	-11	11
Outflow N-organic (kg $ha^{-1}yr^{-1}$)	-123	40	-103	64
Outflow N-erosion (kg ha^{-1} yr^{-1})	-44	26	-28	8
Erosion (tons ha^{-1} yr^{-1})	12,6	4,3	10,1	2,5

Table 8 N-balance and erosion for 'experimental' and 'conventional' farmers

Table 8 shows the N-balance and erosion rates for the households divided over 'experimental' and 'conventional' households. Expected to see is a difference in the total amount of soil loss from erosion and runoff, the experimental having lower soil losses than the conventional household, however the opposite is identified. The conventional farmers have an average soil loss of 10,1 tons per hectare per year and the experimental a soil loss of 12,6 tons per hectare per year. The N outflow from erosion is higher for the experimental farmer than for the conventional farmer. The N-balances however do not show any significant differences and the extra N-inflow compensates the loss.

Economic indicators

The average net farm income is 2 565 birr per farm for the monitoring year (table 5.6). The net farm income (NFI) consists of internal flows within the farming system and is calculated by adding up gross margins of crops, livestock and trade bonus, then subtracting the fixed cost. The trade bonus is a correction for income, based on differences of average prices and received paid prices (see annex-F). Fixed costs are the depreciation costs of the equipment value. All households show positive NFI and it is positively correlated to the gross margins of the PPUs.

Some households show negative cash flows (real outputs being bought and sold). The farm net cash flow is calculated by deducting all cash expenses from cash receipts. The average annual net cash flow amounts -282 birr per farm per year and is negatively correlated to the total cash expenses on livestock (SPU). When comparing livestock expenses and cash receipts, to crop expenses and returns it can be seen that cash expenses on livestock is almost double that of crops. Cash receipts on these activities are however comparable.

Relating this to the sample farmers the negative cash flows of TG03 and TG06 came from high cash expenses and low cash receipts on SPUs. The expenses for those two farmers came from the external import of crop residues as fodder to livestock. They did not produce sufficient residues from yields the previous season and had to buy from outside. The prices of residues vary over the year, in dry season they can be up to thirty birr per

headload and in rainy season prices drop to around 10 birr per headload.

TG05 had low net farm income but showed a positive net cash flow. TG05 has had high cash receipts on the SPU's from the sale of a cow and her calf and sheep. This way TG05 has been able to generate some extra income with the animals acting as a savings.TG07 has a negative cash flow. In the cash flows calculated by NUTMON, credits and cash gifts are not taken up. They are included in family earnings.. That year TG07 received 1300 birr from the husband who is in military service. When this would be taken into account the net cash flow would turn out positive with 1000 birr.

In table 8 it can be seen that on the average there are 412 family labour days available a year. Almost all households invest their labour into on-farm activities, there is little off-farm work. When asked, the farmers answered that there was no off-farm work opportunities in the region. Food-for-work projects are only available to the poorest households and even then it is difficult to join these projects because of the high demand. This is a different observation than was made during the RDA, where the women had ranked Food-for-Work projects as one of the most time consuming activities. The households of TG06 and TG08 are involved in off-farm activities, which include the transportation of salt in the Afar region using their donkeys. The labour spent on off-farm work reflects in the lower crop labour intensity and in higher total family earnings of TG06 and TG08.

The crop labour intensity indicates the number of days spent on cropping activities. The average lies around 171 days per hectare of cultivated area. The total family labour input is related to both the NFI of the household and total area owned.

TG01 has low crop labour intensity because labour input into the farm is relatively low compared to the amount of hectares that he cultivates. There is no real explanation for this because sufficient family labour is available. It could be that because of the recall period of one year that TG01 did not mention all activities resulting in low number of labour days.

Returns to labour are negative for almost all farmers. TG03 and TG07 are the only two households showing positive returns to labour. Returns to labour are based on net farm income minus partial capital costs and capital cost of land divided by the amount farm labour put into the farm (see annex-E). The factors of largest influence on the returns to labour are the NFI and the capital cost of land. In most cases capital cost of land is higher than the net farm income making the returns to land negative. TG07 owns only little land, making returns to labour positive. TG03 owns a lot of land making capital costs relatively high but this is compensated by a high NFI.

Returns to land overall are also negative with -305 birr per hectare a year. The high value of labour input into crops make for four farmers the returns to land turn out negative. Except for TG08 who has a negative return on land even though he uses low labour inputs; this because of a low NFI.

	Farm Code TG									
	01	02	03	04	05	06	07	08	Mean	Stdev
Net farm income (birr farm^{-1} yr^{-1})	3 218	4 399	5 222	3 329	434	1 045	2 122	753	2 565	1 763
Family earning (birr farm^{-1} yr^{-1})	3 218	4 399	5 222	3 329	434	1 267	2 122	949	2 617	1 709
Farm net cash flow (birr yr^{-1})	561	1 536	-3 305	229	558	-1 992	-368	529	-282	1 590
Gross margin ppu (birr yr^{-1})	2 399	6 907	7 106	3 396	474	649	1 438	1 947	3 040	2 621
Gross margin spu (birr yr^{-1})	336	-2547	1750	-318	44	469	691	-325	12	1229
Total gross margin (birr ha^{-1} yr^{-1})	4 143	4 844	3 659	3 946	836	2 727	12 523	1 488	4 271	3 603
Market share (%)	12	17	22	4	32	93	13	15	26	28
Cash receipts stock (birr yr^{-1})	840	505	0	310	0	0	0	0	207	319
Cash receipt PPU (birr yr^{-1})	0	1 119	1 730	405	0	75	700	515	568	608
Cash receipts SPU (birr yr^{-1})	865	1 071	110	225	1 650	102	161	815	625	568
Total cash receipts (birr yr^{-1})	1 705	2 695	1 840	940	1 650	177	861	1 330	1 400	759
Cash expenses stock (birr yr^{-1})	800	170	0	150	561	525	450	0	332	293
Cash expenses PPU (birr yr^{-1})	118	329	226	396	403	122	221	106	240	123
Cash expenses SPU (birr yr^{-1})	179	365	93	507	650	297	1 300	97	436	400
Total cash expenses (birr yr^{-1})	1 145	1 159	3 359	711	1 092	2 169	1 229	407	1 409	936

Table 9 Economic performance indicators

	Farm code TG									
	01	02	03	04	05	06	07	08	Mean	Stdev
Labour units	5	4	6	3	3	2	3	3	4	1
Labour general (days yr^{-1})	160	14	198	102	3	30	14	74	74	74
Labour crop (days yr^{-1})	100	375	539	577	205	71	70	160	262	208
Labour livestock (days yr^{-1})	77	135	104	67	21	66	9	129	76	46
Labour off-farm (days yr^{-1})	0	0	0	0	0	44	0	28	9	17
Total family labour input (day $farm^{-1}$)	337	523	840	746	228	167	92	363	412	270
Hired labour (days)	10	0	6	0	0	0	0	0	2	4
Returns to land (birr ha^{-1})	2 251	337	-1 329	-3 685	-2 829	276	4 196	-1 659	-305	2 624
Returns to labour (birr day^{-1})	-2	-1	0,18	-2	-12	-8	3	-9	-4	5
Returns to off-farm labour (birr day^{-1})	0	0	0	0	0	5	0	7	2	3
Labour intensity crops (days ha^{-1})	84	198	113	397	164	88	254	74	171	111
Labour intensity livestock (days ha^{-1})	10	38	11	15	13	30	7	34	20	12

Table 10 Labour activities Teghane

Crop activity level

An analysis was done on the major cereals and pulses cultivated by the selected households. The farmers of Teghane cultivated (irrigated) barley, faba bean, wheat and black wheat.

	Barley	Barley irrigated	Faba bean	Wheat	Black wheat
	n=19	n=10	n=5	n=6	n=6
Area (ha)	2,83	1,19	0,57	0,71	1,25
Crop yield (kg ha-1yr^{-1})	2 076	2 823	1 841	2 066	1 035
Gross margin (birr ha^{-1} yr^{-1})	4 490	4 365	2 827	2 932	1 267
Net cash flow (birr ha^{-1} yr^{-1})	360	-81	-143	-371	311
Variable costs (birr ha^{-1} yr^{-1})	1 220	1 766	1 067	1 385	994
Variable cost seeds (birr ha^{-1} yr^{-1})	392	359	360	365	279
Variable cost mineral fertiliser (birr ha^{-1} yr^{-1})	120	484	83	297	43
Variable cost hired labour (birr ha^{-1} yr^{-1})	24	13	41	2	7
Variable cost traction (birr ha^{-1} yr^{-1})	684	909	577	722	665
Cash receipts (birr ha^{-1} yr^{-1})	569	505	0	22	462
Cash expenses (birr ha^{-1} yr^{-1})	208	587	143	593	151
N balance (kg ha^{-1} yr^{-1})	-14	6	51	-11	-15
N inflow mineral fertiliser (kg ha^{-1} yr^{-1})	10	49	5	24	4
N inflow organic fertiliser (kg ha^{-1} yr^{-1})	35	19	114	24	5

Table 11 activity level main crops Teghane

The variable costs of seeds are comparable for all five crops, and are around the 400 birr per hectare per year. The variable cost of seed has a considerable influence on the total gross margin. The crop yields and the total variable costs are negatively correlated to each other [???]. The total variable cost is mainly determined by the variable costs of mineral fertiliser input. Also the amount of mineral N input is related to the variable cost of traction.

Assuming that the variable costs give an indication on the importance of a crop, it can be said that barley, both irrigated and rainfed, is the most important crop, it also gives the highest yields compared to the other cereals. Irrigated barley however shows a negative cash flow because of high cash expenses that are not compensated by the returns, but it is quite hard to compare irrigated barley for it is the only crop which is irrigated on large scale by the farmers.

The influence of mineral fertiliser on the yield is quite high and much more of influence than the input of organic fertiliser. On the total N-balance however the organic fertiliser plays a greater role. The crop with the most positive N-balance is faba bean, which can be

explained by it being a leguminous species. Irrigated barley also shows a positive N-balance but, as indicated earlier in this chapter, loss of N through leaching is not taken up in the calculations, which probably means an underestimation of the total N-loss for barley. From the rainfed cereals barley seems to be the best choice when taking into account cash returns and expenses, yield, gross margins and N-balance. Followed by barley is wheat, which had lower cash returns even though yields were comparable.

Summary and Conclusions

On nutrient level there does not seem to be any problem, N-stock has been refilled and even extra N has gone back into the farming system for all selected households, making the system, for at least this monitoring year, sustainable on basis of total N-balance. When comparing the average amount of soil loss, of the sample farmers in Teghane, with existing literature, soil losses do not seem that high. However it still is substantially higher than soil formation rate, resulting in a loss of nutrient rich topsoil and reducing the soil depth, both factors affecting sustainable crop production.

The number of soil and water conservation structures in this study is positively correlated to the area of land cultivated and to the total amount of nitrogen lost from the field. The last could however be coincidence, because N loss from erosion and total soil losses are not related to the number of stone and soil bunds (see annex-K). From this result it seems that the Soil and water conservation measures of stone bunds are not effective in reducing soil losses. There was no relation found between soil loss, (partial) N-balance and household income.

The gross margins of the PPUs are high compared to that of the SPUs that are mostly negative. On average however the total gross margin is slightly positive. The cash expenses compared to the receipts are a lot higher for livestock than they are for crops. Livestock in the monitoring year was not very cost-effective. The net cash flows for SPUs turned out to be negative with 200 birr and the crops show a positive net cash return of a little more than 300 birr. Opportunities here lie in the improvement of crop outputs for higher crop residue production, but also grazing management and opportunity of increasing the feeding value of residues supplied to the animals, needs further attention. Farmers indicated that the communal grazing area had not provided sufficient feed for the animals and this had been the case for the previous years as well, indicating that livestock density is high and putting a lot of stress on the grazing areas. Reducing the number of animals, especially large ruminants, which need a lot of feed, would improve the communal grazing area and reduce the expenses on livestock for the household.

Teghane has high agricultural potential having access to irrigation and with the market being close at hand. Improving agricultural production using higher levels of external inputs will increase food security and income levels. Having higher income levels makes it easier to take risks and invest. The sample farmers experiencing negative cash flows, were those with high Net Farm Incomes (NFI), they were able to take a risk of negative cash flows. Farmers who have low Net Farm Income try to keep the cash flows positive.

When looking at the NFI, TG03 can be identified as wealthiest household of all the selected households in Teghane. It is however also the household who had a negative cash

flow of more than 3 000 birr highest of all sample farmers. TG03 found that he could take the risk. From the research it can be concluded that for the sample households having low net farm incomes they, focus on returns on short-term basis and try to keep net cash flows positive over that year. Wealthier farmers in terms of assets take higher risk, and affording themselves to have negative cash flows over a year. Farmers like TG03 have development opportunities. TG03 cultivates a relatively large amount of land and shows that he takes risks and may be willing to invest in for example commercial crops increasing cash income or other technologies such as fertiliser, improved seed or animal breeds.

The irrigation area of Teghane is not used to full potential. Only 35 hectares from the 70 hectares are being used. From the sample farmers only one was using the irrigation area for cultivating a second crop in one season. It was not clear what constraints made farmers to grow only one crop per season. Farmers identified water logging to be a big problem, especially for those plots positioned directly behind the dam. Furthermore because of earth canals, waterlosses occur due to infiltration. The irrigation area is important to the farmers, as was already indicated during the RDA. The loss of grazing area is compensated by the extra production of crop residues. It should therefore be looked at what improvements could be made to increase use of the irrigation area in a sustainable way. The most profitable crop to the sample households was barley. From the analysis it turns out to be the most profitable crop having the highest benefits with the lowest costs. It is also the most cultivated crop in this area. Wheat gives comparable yields to barley, but revenues are low because of lower market prices and relatively high costs of mineral fertiliser compared to yield outputs. It would be interesting to see if there are other crops than barley that could be cultivated to see if it is indeed the most profitable cereal crop or if there are other crops, which would give higher yields especially on the irrigated area. Experimentation is needed with improved seeds and crop types to be able to reach full potential.

The irrigation area has large potential for extra crop outputs improving food security and income. Growing cash crops and fodder cropswould be new ways of increasing the potential with fodder crops reducing the stress on grazing area. For this strategy however land scarcity and the small plots are still constraints. Larger cultivated areas have higher potential because of lower risk to investment. This can be related to those sample households who have share cropped in large amounts of cultivable land. These were often identified as the richer ones.

Off-farm opportunities should, if possible, be increased, so that stress on farming land reduces. For farmers who experience difficulties in surviving in farming, because of -for example- lack of assets, off-farm work gives them other opportunities to make a another living. Households TG06 and TG08 show that off-farm work in the Afar region is more profitable for them than farming. Share cropping out their land and working off-farm could be an option to increase income and have some crop output from the share cropped land, like for example TG07 is doing.

CHAPTER 5 NUTMON Gobo Deguat

Introduction

This chapter describes the results for each selected farmer in Gobo Deguat. It starts with analyses on the farming system of Gobo Deguat including basic farm characteristics, the cultivated crops, N-balances, economic indicators and the activity level of the major crops cultivated.

Farm System Analyses Gobo Deguat

General Farm Characteristics

The basic farm characteristics of the selected households of Gobo Deguat can be found in table 12. The average number of persons in the household is seven of which there are almost three labour units. The average area cultivated is 0,29 hectares. The level of mechanisation is low and the equipment has an average value of 190 birr. Most common implements are the animal drawn plough and the sickle. The animal drawn plough is the most capital-intensive implement and has a real price of around 30 birr and was given a shadow price of 75 birr.

None of the farmers sharecrop out land, but six out of the ten farmers share crop in. In the RDA the farmers indicated that share cropping in land is a way increasing their total cultivated area and in this way also increasing the total output reducing the risk of not producing enough food for subsistence level.

Table 12 shows that GD06 has no land of his own. During the monitoring period it became clear that he was taking over the farm of his father, for now he was still share cropping all cultivated land with his father. Father and son however do not share the same households.

The number of PPUs indicates a high number of plots, but the households only have a total area of less than half a hectare including share cropped in land. The plots are very small, often scattered over the area and sometimes difficult to reach for the farmers. The diversity in crops is quite high which indicates risk spreading. There does not seem to be any relation to the amount of land owned and the equipment or livestock owned.

	Farm ID GD											
	01	02	03	04	05	06	07	09	10	11	mean	stdev
Class	CF	CF	CF	EF	EF	EF	EF	EF	EF	EF		
Number of household members	7	5	7	9	10	6	4	6	9	7	7	2
Labour unit	1,64	2,35	3,25	2,88	3,88	2,45	2,25	2,13	4,03	3,35	2,82	0,79
Consumer unit	4,86	3,70	5,35	6,67	7,50	4,45	3,25	4,45	6,75	5,05	5,20	1,38
Total area (ha)	0,45	0,50	0,68	0,39	0,65	0,61	0,56	0,32	0,56	0,86	0,56	0,16
Total area owned (ha)	0,38	0,49	0,68	0,35	0,65	0	0,56	0,32	0,47	0,81	0,47	0,23
Average area sharecropped in (ha)	0,06	0,01	0	0,04	0	0,61	0	0	0,09	0,06	0,09	0,19
Average area cultivated (ha)	0,19	0,25	0,40	0,24	0,36	0,39	0,24	0,20	0,21	0,38	0,29	0,09
Total value equipment (birr)	108	122	330	284	300	177	108	115	182	177	190	85
Total value livestock (birr)	7 750	2 461	2 773	5 870	6 667	9 241	6 055	2 167	10 472	7 710	6 117	2 876
Total value land owned (birr ha^{-1})	4 411	5 694	7 835	4 079	7 448	0	6 396	3 675	5 366	9 289	6 021	1 889
Total capital (birr)	12 269	8 276	11 021	10 233	15 441	9 418	12 559	5 957	16 292	17175	11 864	3 627
Number of FSU	4	6	5	4	8	5	8	3	7	6	6	2
Number of crop types	5	6	7	4	4	5	5	3	7	7	5	1
Number of PPU	13	14	15	10	16	12	16	8	16	18	14	3
Number of TLU	4,96	1,28	1,23	3,41	4,30	5,88	3,88	1,05	5,81	5,12	3,69	1,89

Table 12 Basic farm characteristics Gobo Deguat

	CF (n=3)		EF (n=7)	
	Mean	Stdev	Mean	Stdev
Number of household members	6	1	7	2
Labour unit	2	1	3	1
Consumer unit	5	1	5	2
Total area (ha)	0,54	0,10	0,56	0,18
Total area owned (ha)	0,52	0,12	0,45	0,26
Average area sharecropped in (ha)	0,02	0,03	0,11	0,22
Average area sharecropped out (ha)	0,00	0,00	0,00	0,00
Average area cultivated (ha)	0,28	0,09	0,29	0,08
Total value equipment (birr)	186	102	192	75
Total value livestock (birr)	4 328	2 423	6 883	2 681
Total value owned land (birr ha^{-1})	5 980	1 412	6 042	2 124
Total capital value (birr)	10 522	1 668	12 439	4 130
Number of FSU	5	1	6	2
Number of crop types	6	1	5	2
Number of PPU	14	1	14	4
Number of TLU	2	2	4	2

Table 13 General farm characteristics averaged over 'Experimental Farmer' and 'Conventional Farmers

Table 13 shows the general farm characteristics for the farmers averaged over the conventional farmers (CF) and the experimental farmers (EF). There are no large differences to be observed between the two farmer types. The experimental farmer can be seen as little richer than the conventional farmer, he owns on average a little more livestock, land, and equipment.

Cultivated Crops and yields

Cereals and pulses cultivated were *hanfest,* barley, wheat and maize. *Hanfest* is the Tigrinian name for the mixture barley and wheat crop, grown by almost all farmers in Gobo Deguat. It was not possible to measure the crop ratio in the field. In Woldeamlak (2001) research has been done on *hanfest* cultivated in Eritrea where a barley/wheat ratio of 3:1 was found and sometimes 1:1, it is reasonable to assume that this is also the case for the *hanfest* in Northern Ethiopia. Reasons for sowing *hanfest* is a higher total yield, better yield stability, better food quality, better animal feed and resistance to pests (Woldeamlak et al., 2001). This seems to be confirmed by this study when looking at the average yields, hanfest having the highest of all main cereals.

Two farmers grew Teff the year previous to the monitoring year, but none of the farmers were cultivating during the monitoring year. It was mostly grown in rotation with other cereal crops as barley and wheat.

Pulses include faba bean and lentil. Problem that farmers indicated with faba bean is that it is sensitive to waterlogging; two farmers have lost their yield due to this. The residues

from these failed crops are left on the field and livestock is brought to it to feed on it. Yields of all main crops are shown in table 14. The mean yields and variances are averaged over the households.

Crops	Yields (Quintal ha^{-1} yr^{-1}) Farm Code GD											
	01	02	03	04	05	06	07	09	10	11	mean	Stdev
Barley	19,6		5,7	5,0	3,6		5,3			0,5	6,6	6,7
Black Wheat						12,5	7,1		31,3	2,3	13,3	12,7
Faba Bean			6,5	5,0	2,0				1,6	6,8	4,4	2,45
Finger Millet	20,8	5,0				5,1		6,0			9,2	7,7
Hanfest	10,6		16,0		14,8	40,0	9,0		10,8	2,1	14,8	12,0
Maize	20,8	7,5	2,3			28,6		5,0			12,9	11,3
Millet		3,3					3,2	2,3			3,0	0,5
Wheat	20,8	3,8	4,3	18,8							11,9	9,1
White Wheat									7,1	5,1	6,1	1,5

Table 14 Average crop yields Gobo Deguat

The average yield for barley is 660 kilograms per hectare and is lower than the average yield per hectare found for Tigray in 2001, which is 840 kilograms per hectare (FAO/WFP Jan, 2002). Barley, maize and finger millet yields are all on average higher than the average over Tigray (see table 15).

Crop	Yield ($kg\ ha^{-1}$)
Wheat	970
Barley	840
Maize	1110
Finger Millet	770
Other	880

Table 15 Average yields for Tigray 2001 (FAO/WFP Jan 2002)

The yields per farmer per crop show great variances. GD11 for example has very low yields and GD01 very high. It could be because outputs are estimations of the farmers on the yields of the previous year.

Crop failure has also occurred with GD07 where rabbits had eaten most of the seedlings and destroyed the whole crop. Other farmers have indicated monkeys also a being a large problem threatening the harvest. When standing on the field the crops have to be guarded day and night from the monkeys.

Prickly pear fruit (*Opuntia Ficus-indica)* is a very important additional food source in Gobo Deguat during the dry season and I have chosen to take the cactus up in the farming system. Some farmers have said that during severe droughts the only food consumed is the cactus fruit.

Livestock also benefits from the cactus. The leaves of the cactus form a complementary

feed for cattle. Fruit yields were very high, of over more than 1 000 quintal, and were based on the number of fruits (one fruit is equals 150grams) farmers indicated the household eat each day from June till August. There were no external nutrient inputs going into the cacti. Most of the households had prickly pear standing near the farmhouse and harvest the fruits. One household had started fertilising their prickly pear area with ash, thus emphasising the importance of the prickly pear.

Nutrient balance

Table 16 shows a negative total N-balance. This indicates that farmers lose N: more N goes out of the system than there goes into it. There is a total mining of the N-stock at an average of 46 kilograms of hectare per year. The difference between the partial N-balance and the total N-balance is quite high, the partial balance is slightly positive, which indicates that a lot of N is lost through the hard to quantify flows. No estimates are available for the N loss in Tigray but for Ethiopia as a whole the losses of N were estimated on 41 kilograms of N per hectare per year for 1983 and predicted to be much higher in the year 2000 (Stoorvogel en Smaling, 1990).

Erosion (OUT5) is the main cause of the loss of N in the hard to quantify flows, followed by removal of harvested products and crop residues. The total soil loss through erosion has an average of 21 tons per hectare per year but varies among the farmers. GD06 and GD07 have soil losses of 60 and almost 80 tons per year also making the average soil loss very high, but the other farmers barely reach the 10 tons of soil loss per year. The plots of the GD06 and GD07 have very steep slopes of over twenty percent having large influence on total soil loss. The 21 tons of soil loss a year in Gobo Deguat is still lower than the estimated soil erosion loss rate by Hurni (1987) of 42 tons per hectare per year, but it is significantly higher than soil formation rate.

External N-inputs compensating the nitrogen losses are very small. Farmers only use little mineral fertilisers input. Some farmers like GD02, GD06 and GD09 do not use any mineral fertilisers, resulting in an average inflow of N over the ten households of only six kilograms per hectare. Most N-input is organic and comes from livestock manure and compost applications. It was already identified earlier during the RDA that fertiliser use is not very common in Gobo Deguat, because fertilisers are too expensive for most farmers and benefits in terms of yield increases are uncertain.

	Farm Code GD											
	01	02	03	04	05	06	07	09	10	11	mean	stdev
Class	CF	CF	CF	EF	EF	EF	EF	EF	EF	EF		
Area (ha)	0,45	0,50	0,68	0,39	0,65	0,61	0,56	0,32	0,56	0,86	0,56	0,16
N-balance (kg ha^{-1} yr^{-1})	-58	39	-25	-0,23	-4	-172	-151	-32	-9	-50	-46	67
(N balance kg $ha^{-1}yr^{-1}$	*-54*	*40*	*-20*	*9*	*-4*	*-148*	*-151*	*-32*	*1*	*-50*	*-41*	*64)*
Partial N-balance (kg ha^{-1} yr^{-1})	-46	60	2	28	38	-92	-7	-11	45	-5	1	45
Inflow N mineral fertiliser (kg ha^{-1} yr^{-1})	23	0	1	6	14	0	4	0	12	3	6	8
Inflow N organic fertiliser (kg ha^{-1} yr^{-1})	16	67	13	46	31	4	4	17	79	4	28	27
Outflow N products (kg ha^{-1} yr^{-1})	-82	-3	-1	-9	-1	-95	-7	-10	-17	-3	-23	35
Outflow N organic (kg $ha^{-1}yr^{-1}$)	-3	-4	-13	-16	-6	-4	-9	-17	-28	-9	-11	8
Outflow N erosion (kg ha^{-1} yr^{-1})	-5	-14	-18	-4	-17	-69	-124	-2	-36	-20	-31	38
Erosion (ton ha^{-1} yr^{-1})	5,5	12,2	10,1	2,0	6,6	60,9	79,5	1,5	21,7	9,8	21,0	26,9

Table 16 N-Flows and Erosion level

Table 17 shows the same table but divided over the 'experimental' and 'conventional' farmer groups. The experimental farmers are those selected as active in Soil and water conservation measures and the conventional farmers as those less active. From table 17 the opposite of what is expected is seen, the experimental farmer has higher average soil losses than the conventional farmer has, 26 tons per hectare per year compared to 'only' 9 tons per hectare per year. The outflow of N per hectare for the experimental farmers is double that for the conventional farmer. Again GD06 and GD07 are the main cause for the high N outflows concerning the experimental farmers.

	CF (n=3)		EF (n=7)	
	mean	stdev	mean	stdev
N-balance (kg ha^{-1} yr^{-1})	-15	49	-60	72
Partial N-balance (kg ha^{-1} yr^{-1})	5	53	-0,4	46
Inflow N mineral fertiliser (kg ha^{-1} yr^{-1})	8	13	5	6
Inflow N organic fertiliser (kg $ha^{-1}yr^{-1}$)	32	30	27	28
Outflow N products (kg ha^{-1} yr^{-1})	-29	46	-20	33
Outflow N erosion (kg ha^{-1} yr^{-1})	-7	5	-13	8
Outflow N erosion (kg $ha^{-1}yr^{-1}$)	-12	6	-39	44
Erosion (ton ha^{-1} yr^{-1})	9,3	3,4	26,0	31,4

Table 17 N-balance and erosion 'Experimental Farmer' and 'Conventional Farmer' in Gobo Deguat

Economic Indicators

The average Net Farm Income (NFI) is 1 689 birr per farm per year (table 18). Only GD01 has a negative NFI, the gross margins indicate that this stems from large negative gross margins from SPUs. The net farm income varies a great deal per household, from -202 birr of GD01 to 3 096 birr for GD10. The net farm income is closely linked to the gross margin of the SPUs. When looking at for example GD01 his livestock management correlates to the negative NFI. GD01 has been selling and buying quite some livestock, but the reason for the negative gross margin is the sale of one of his oxen and the death of his only sheep. Livestock has a high value and influences the NFI therefore easily. When looking at his family earnings that include earnings from off-farm labour, GD01 has above average earnings and thus does quite well on total economic performance.

Average annual net cash flow is -135 birr per farm per year. No relation can be found between the NFI and the net cash flow. The net cash flows differ per household on factors influencing it. Cash flows are not that high in value and are averages over one year. The sale of livestock is the main reason why cash flows turn out positive.

Cash expenses on crops are quite a lot lower per farm than on livestock, but it varies a great deal per farm. The cash receipts on livestock however are again a lot higher compared to the receipts on crops, which makes cash flows of the two activities

comparable.

The average number of family labour days (see table 19) including off-farm work is 306, almost one full time person a year. All of the households work off-farm. The off-farm work of GD01 and GD03 consists off-farm labour at *Humera* where mechanised farming takes place. All households participate in Food for Work projects. A few other households participate in smaller off-farm community services such as GD02, who gives trainings on the construction of kitchen furnishing and hygiene, and GD10 is an agricultural agent and gives trainings to farmers for which he gets paid in kind.

Off-farm labour demand is high but employment opportunities are lacking. Even in *Humera* where mechanised farming takes place, there are not enough labour opportunities available to satisfy the high demand. Farmers such as GD01 and GD03 went there for off-farm work. During their stay they were dependent on the work available per day, some months they had work for almost every day other months they only worked a few days. The distance and the insecurity of work however was more profitable than staying in Gobo Deguat and putting their labour to use on their farms. Returns on off-farm labour came out a lot higher in this study than returns on on-farm labour.

Taking the average over the households, returns on family farm labour are barely positive. GD02 has the highest return to labour of 22 birr per day compared to an average of one birr a day. GD02 is the only female-headed household. She has a high net farm income because gross margins on SPU were high, her herd growth was positive, many young animals were born and some were given to her as gift. This has effect on the returns to labour. For GD02, also total family labour is quite low compared to the other farms with only 102 days a year (see table 19) while the average lies around the 300 days a year. Because GD02 is a female headed household, she gets a lot of labour on her farm for free coming from relatives. She does not participate in ploughing activities, because of the cultural taboo, which further reduces the amount of time spent on on-farm labour.

GD01 is the only household with high negative returns to family labour, which is caused by a negative net farm income. GD01 also has high partial capital cost (value of land and livestock times the interest rate) making returns even lower. Off-farm returns are quite high, the average is six birr a day and this comes close to the real price of wage labour of 10 birr a day. Average returns to land are positive with 90 birr but with wide range. Because of the NFI being negative for GD01, returns to land turn out negative. The returns to land for GD06 are set to zero because he technically does not own any land, all land he cultivated was share cropped in.

	Farm Code GD											
	01	02	03	04	05	06	07	09	10	11	mean	Stdev
Class	CF	CF	CF	EF	EF	EF	EF	EF	EF	EF		
Net farm income (birr farm^{-1} yr^{-1})	-202	2 832	2 169	574	2 314	2 879	1 224	1 615	3 096	385	1 689	1 158
Family earnings (birr farm^{-1} yr^{-1})	2 685	2 923	2 537	674	2 446	2 959	1 292	1 703	3 409	449	2 108	1019
Farm net cash flow (birr farm^{-1})	-465	-37	-390	-86	-653	966	-328	-1 286	1 223	-144	-120	736
Gross margin PPU (birr yr^{-1})	3 191	889	1 315	960	2 658	3 794	1 081	675	984	799	1 635	1 135
Gross margin SPU (birr yr^{-1})	-2 270	1 350	855	-231	-249	670	304	1 214	1 640	-361	292	1 145
Market share (%)	25	1	12	5	14	17	13	60	28	7	18	17
Cash receipts stock (birr yr^{-1})	478	0	18	0	0	303	25	0	11	198	103	168
Cash receipts PPU (birr yr^{-1})	90	67	55	188	10	1 778	60	126	250	66	269	535
Cash receipts SPU (birr yr^{-1})	663	1 118	0	108	270	645	116	116	1 464	78	458	502
Total Cash Receipts (birr ha $^{-1}$yr^{-1})	2 735	2 370	107	758	431	4 469	358	757	3 080	396	1 546	1 501
Cash expense Stock (birr yr^{-1})	900	835	375	0	750	0	452	975	56	356	470	378
Cash expense PPU (birr yr^{-1})	173	35	56	132	177	8	76	4	160	68	89	173
Cash expense SPU (birr yr^{-1})	503	350	31	152	6	1 032	1	550	185	45	285	503
Total Cash Expense (birr ha^{-1} yr^{-1})	3 502	2 440	680	727	1 435	1 705	944	4 777	717	546	1 747	1 421

Table 18 Labour indicators Gobo Deguat

	Farm Code GD											
	01	02	03	04	05	06	07	09	10	11	mean	Stdev
Labour unit	2	2	3	3	4	2	2	2	4	3	3	1
Total labour general (days yr^{-1})	3	1	1	48	1	1	2	2	4	2	6	15
Total labour crops (days yr^{-1})	89	42	302	29	321	341	68	199	327	395	211	142
Total labour livestock (days yr^{-1})	45	38	46	21	0	147	35	12	80	47	47	42
Labour off-farm (days yr^{-1})	140	21	47	45	33	20	37	22	32	16	41	36
Total family labour (days yr^{-1})	278	102	395	144	355	509	142	235	443	461	306	147
Hired labour (days yr^{-1})	10	0	0	2	1	0	0	0	0	0	1	3
Returns to family labour (birr day^{-1})	-13	22	2	-7	1	3	-3	4	3	-4	1	9
Returns to off-farm labour (birr $^{-1}$ day^{-1})	21	4	8	2	4	4	2	4	10	4	6	6
Returns to land (birr ha^{-1})	-4 020	4 730	828	-881	123	NA	324	1 667	902	-2 701	97	2 378
Labour intensity crops (days ha^{-1} yr^{-1})	110	48	255	43	273	293	64	324	329	230	197	117
Labour intensity livestock (days ha^{-1} yr^{-1})	9	29	37	6	0	25	9	11	14	9	15	12

Table 19 Economic performance indicators Gobo Deguat

Crop activity level

From the major crops cultivated by the selected farmers shown in table 20 can be seen that *hanfest* is the most important crop. It had the highest average yield, covered the largest area and had highest variable costs, which gives an indication of the total input into the crop. Hanfest is comparable to wheat on almost all indicators. Wheat had lower variable costs but net cash flow was higher for *hanfest*, which makes *hanfest* prefered over wheat.

The cash flows and cash receipts are positively correlated to the yields. The seed inputs were the highest variable costs followed by traction.

There is not much mineral fertiliser used on the crops. The most intensive use of the mineral fertiliser was on barley with an external N inflow through fertiliser use of 39 kilograms per hectare a year. Yield returns on barley were however low, only 617 kilograms per hectare compared to the other cereals cultivated. It shows how uncertain the extra benefits are of mineral fertiliser. For farmers it is quite a risk to use them if returns do not increase substantially. Outputs in Gobo Deguat are more related to the organic N-inflow than to the amount of N mineral fertiliser applied.

	Barley n=7	Black wheat n=7	Faba bean n=6	Hanfest n=11	Maize n=5	Wheat n=5
Total area (ha)	0,83	0,55	0,41	1,11	0,50	0,15
Yield (kg $ha^{-1}yr^{-1}$)	617	860	473	1 350	1 286	1 328
Gross margin (birr $ha^{-1}yr^{-1}$)	2 535	2 799	1 683	5 455	4 629	5 842
Net cash flow (birr $ha^{-1}yr^{-1}$)	-445	219	-92	987	1 013	620
Variable cost (birr ha^{-1} yr^{-1})	985	1 393	489	1 677	456	1 530
Variable cost seed (birr ha^{-1} yr^{-1})	343	704	558	1 123	269	1 333
Variable cost min. fert (birr^{-1} ha^{-1} yr^{-1})	377	163	0	133	0	0
Variable cost hired labour (birr $ha^{-1}yr^{-1}$)	13	0	13	20	17	22
Variable cost traction (birr $ha^{-1}yr^{-1}$)	252	527	220	393	169	176
Cash receipts (birr $ha^{-1}yr^{-1}$)	9	463	0	1 177	1 127	938
Cash expenses (birr $ha^{-1}yr^{-1}$)	454	244	92	189	115	317
N balance (kg $ha^{-1}yr^{-1}$)	19	-23	25	-17	-211	-13
N inflow mineral fertiliser (kg $ha^{-1}yr^{-1}$)	40	10	0	8	0	0
N inflow organic fertiliser (kg $ha^{-1}yr^{-1}$)	5	6	47	21	21	22

Table 20 Activity level different crops Gobo Deguat

Barley and Faba Bean were mainly used for own consumption also because yields turned out low that year and there were no surpluses. Maize is compared to the other crops had very high N-losses, it was however profitable in terms of cash flows. Furthermore variable costs of maize were quite low because seed was relatively cheap and there were no costs

on mineral fertilisers. The high losses of N from maize are from output of crop product. Barley and faba bean were the only crops with positive N balances. Faba bean is leguminous crop, and the positive N-balance is from the N-fixation of the crop. The N-balance for barley was positive because of the relatively high mineral fertiliser use.

Overall, maize seems to be the most profitable crop in terms of cash returns and it also has low cash inputs, however quite some N was depleted from the soil with the harvest. Taking cash income and nutrient management into account it would be best to cultivate *hanfest* or wheat.

Summary and conclusions

A summary on the averages is hard to give, because each farmer seems to have its own way of farming. Relationships were not very clear between different economic indicators and nutrient balances.

Farmers vary a lot in management practises from each other, but what they have in common is that the area of land they own is about half hectare. Land is a large constraint; there are many small plots everywhere on steep slopes, sometimes of more than 25%. The N-balance is negative over almost all households, which means that N-stock is being mined The average partial N-balance however is just positive indicating that most losses stem from hard to quantify flows. The total N-balance is related to loss of N through erosion and the partial N-balance shows high losses through crop outputs. There was no relation of the N-balance to the NFI or cash flows. I have also looked at a relationship between the number of soil bunds (see annex-L) and the amount of soil loss, but there was not a clear relation. The number of bunds is related to the amount of land owned. There was no apparent relation to the type of household and the N-balances. N-inflows in general, are quite low and consist mostly of organic nitrogen in compost and manure. Yields react to an increase in mainly organic N. The average yields of the major cereal crops are above the average of Tigray, but still too low for self sufficiency. The benefit of the external input of mineral fertiliser was not apparent from the results. This could be due to the low number of farmers using it.

Total family labour returns were low, on average just one birr a day. Returns to off-farm labour are higher. REST is already active in the area, providing off-farm work in the form of food for work (FFW) by constructing check dams in the gully. The grain earned from the FFW improved food security of the households. This off-farm work will only last until the checkdams are constructed. Other off-farm work opportunities are minimal and available only if farmers are willing to travel the distance to Afar or Adigrat with their donkey: even this extra income is more profitable than farming. There were three farmers who had started bee keeping as a form of extra cash income. Queen bees are sold at very high prices

Expenses on livestock are quite high, often because of input of external residues. Even with the extra residue import, livestock (especially cattle), did not receive sufficient feed as identified in the model. The amount of residue needed is related to yields and to the type of livestock . A change to smaller ruminants would reduce the demand for residue. This is unlikely to happen, because of the important cultural status cattle has in the Ethiopian culture.

Gobo Deguat is an area of low potential and poor market access. Development opportunities are hard to identify. Improvement in off-farm labour opportunities, market access and infrastructure do not seem likely to happen in the short run. Also the uncertainties concerning rainfall and the small plots of half a hectare make it risky to invest in new technologies. In Gobo Deguat development opportunities probably lie in poverty alleviation and increasing food security. Almost all sample households were relying for part of their food supply on Free Food Aid. Yields have to be increased in order to make the households less dependent on food aid from outside.

From the study made on the crops cultivated by sample farmers, *hanfest* showed highest potential with the lowest risk for at least the monitoring years. Experimenting with *Hanfest*, by using improved seeds and changing barley/wheat ratios may increase yields. Further yield improvements can be achieved by reducing the soil and nitrogen losses through erosion, combined with higher inputs of fertilisers. Given the relatively low opportunity costs of labour extra labour investment in soil and water conservation works could be part of the strategy in reducing soil and nutrient losses. However, in the RDA the farmers had indicated that they lack the energy for labour needed on extra conservation measures. The soil and water conservation measures should be therefore be combined with extra fertiliser input. The reason for the lack of external fertiliser input lies in the high costs; subsidised fertiliser would maybe be an option. Importing subsidised fertiliser is likely to be cheaper than importing grains (Hagos 1999).

Despite the opportunities mentioned here it does not seem very likely that this area will change the long-term poverty the community is facing also the area is already badly degraded, returns on external inputs, like mineral fertiliser, may be too low or too risky for farmers to use in substantial amounts. Food aid would therefore still be needed to complement the deficits. As seen in the history mentioned in the RDA, emigration is an important part of the livelihood strategies already applied to this area. Emigration reduces the stress on the natural resources and may be the best solution for the area.

In the short term activities like stabilising the gully are an important part of trying to reduce the further degradation of the area. NGO’s like REST play an important part in trying to stabilise erosion, in this case by applying checkdams in the gully and increasing food security by supplying grains. Government plays an important role in facilitating access to external inputs and other extension services, but also facilitating emigration opportunities.

CHAPTER 6 Comparative Analysis of Teghane and Gobo Deguat

Introduction

This chapter compares the two sites on the indicators discussed in chapters five and six. Chapters five and six have covered most of this but by taking averages over the farms information is lost and for such a small sample size averages do not tell us that much. For this thesis it is interesting to see the differences between a site like Teghane with many development opportunities and Gobo Deguat a low potential area with poor market access.

Comparative analysis

General farm Characteristics

The average area cultivated in Teghane is one and a half times larger than that of Gobo Deguat; furthermore the amount of livestock indicated in TLUs and the value of equipment is higher in Teghane than in Gobo Deguat even though they are compared to shadow prices in Gobo Deguat. This makes the total capital value on assets three times as high for Teghane than for Gobo Deguat. Households in Teghane are clearly wealthier, which of course can be expected.

The number of household members, FSUs and PPUs are equal at both sites (table 21). There is also little difference in the number of different crops cultivated the type of crops cultivated however do differ and the main crops cultivated are shown in table 22 together with the average yields that were recorded. The frequency (n) indicates the number of plots on which the crops were cultivated.

	Teghane		Gobo Deguat	
	mean	stdev	mean	stdev
Number of household members	7	2	7	2
Labour Unit	3,58	1,22	2,82	0,79
Consumer Unit	5,58	1,47	5,20	1,38
Total Area (ha)	0,88	0,64	0,56	0,16
Total area owned (ha)	0,66	0,19	0,47	0,23
Average area sharecropped in (ha)	0,24	0,52	0,09	0,19
Average area sharecropped out (ha)	0,02	0,04	0,00	0,00
Average area cultivated (ha)	0,46	0,36	0,29	0,09
Total value equipment (birr)	244	136	190	85
Total value livestock (birr)	3 167	2 233	6 117	2 876
Total value owned land (birr ha^{-1})	26 811	8 199	6 021	1 889
Total Capital Value (birr)	30 222	9 632	11 864	3 627
Number of FSU	6	2	6	2
Number of crop types	4	2	5	1
Number of PPU	14	5	14	3
Number of TLU	4,26	2,69	3,69	1,89

Table 21 General Farm Data Teghane and Gobo Deguat Cultivated Crops and Yields

Major crops cultivated at both sites are barley, wheat, black wheat and faba bean. Gobo Deguat cultivates *hanfest* as major cereal crop and for Teghane this is barley. The results show that a reason for cultivating barley by the sample farmers is because returns on barley are higher with higher inputs than they are for *hanfest*. Teghane achieves the highest yields and the largest differences in yields are found for barley and faba bean. It is clear from the table 22 that Teghane has the higher average crop yields and this can be explained by the higher external inputs per crop (see table 23).

	Average Yields (kg ha^{-1} yr^{-1})								
	Teghane				Gobo Deguat				Tigray
	n	Area (ha)	Mean	Stdev	n	Area (ha)	Mean	Stdev	
Barley	19	2,8	2 076	1 530	7	0,8	617	625	840
Wheat	7	0,7	2 066	1 723	5	0,2	1 328	956	970
Faba Bean	6	0,6	1 841	1 256	6	0,4	473	235	940
Black Wheat	6	1,3	1 035	405	7	0,6	860	1 085	880
Barley Irrigated	12	1,2	2 823	1 984					
Hanfest					11	1,1	1 350	1 140	880
Maize					5	0,5	1 286	1 130	1 110

Table 22 Average yields Teghane and Gobo Deguat

Nutrient Balance

The N-balance is negative in Gobo Deguat. Although N-outputs from production in Teghane were very large, N-balance stayed positive because of the external inputs. In Teghane all farmers had the means to mineral fertiliser and they all applied it on their land. The N-inflow through fertiliser uses for Teghane is a factor nine larger for mineral fertiliser and a factor eight for the organic inputs. In Gobo Deguat eight of the ten farmers did not use any mineral fertiliser input, all extra N-inputs were from organic sources. The difference in N organic inflow is related to the difference in the number of livestock owned, with Teghane having more livestock and thus producing more manure.

Erosion levels are much higher in Gobo Deguat this can be related to the steeper slopes of the cultivated plots. The N loss in Gobo Deguat mainly comes from the N loss by erosion but in Teghane N loss is mainly caused by the loss of N through the harvesting of the crops.

	Teghane		Gobo Deguat	
	Mean	Stdev	mean	stdev
N-Balance (kg ha^{-1} yr^{-1})	100	68	-46	67
Partial N-Balance (kg $ha^{-1}yr^{-1}$)	164	80	1	45
Inflow N-mineral fertiliser (kg $ha^{-1}yr^{-1}$)	18	15	6	8
Inflow N-organic fertiliser (kg ha^{-1} yr^{-1})	272	146	28	27
Outflow N-products (kg $ha^{-1}yr^{-1}$)	-14	13	-23	35
Outflow N-organic (kg $ha^{-1}ha^{-1}$)	-113	58	-11	8
Outflow N-erosion (kg ha^{-1} yr^{-1})	-36	22	-31	38
Erosion (tons ha^{-1} yr^{-1})	11,4	4,0	21,0	26,9

Table 23 N-balance and erosion Teghane and Gobo Deguat

Economic Indicators

The net farm income (NFI) shows that on average, housekods in Teghane earn 1 000 birr per hectare per year more that in Gobo Deguat.The gross margin is around 900 birr per hectare more in Teghane. Off-farm labour contributes more to the total family earnings in Gobo Deguat than it does in Teghane. Receipts on crop and livestock in Teghane are double the amount of Gobo Deguat, but expenses are almost triple. Net cash flows per hectare on crops for Teghane are a little less than 500 birr per year and for Gobo Deguat a little more than 300 birr per year. For net cash flows per TLU on livestock for Teghane is only eight birr per TLU per year and for Gobo Deguat 43 birr per TLU per year. These indicators all show that the sample farmers of Teghane have higher economic wealth (see also table 24)..

	Teghane		Gobo Deguat	
	Mean	Stdev	mean	Stdev
NFI (birr ha^{-1} yr^{-1})	4 077	3 797	3 137	2 166
Family earnings (birr $ha^{-1}yr^{-1}$)	4 714	3 651	4 013	1 953
Farm net cash flow (birr ha^{-1} yr^{-1})	-519	2 163	-391	1 658
Gross margin ppu (birr ha^{-1} yr^{-1})	3 902	2 826	3 030	2 081
Gross margin spu (birr tlu^{-1} yr^{-1})	14	349	273	528
Market share	26	28	18	17
Cash receipts stock (birr yr^{-1})	207	319	103	168
Cash receipt PPU (birr ha^{-1} yr^{-1})	906	1361	485	870
Cash Receipts SPU (birr TLU^{-1} yr-1)	238	344	162	261
Total Cash Receipts (birr yr^{-1})	1 351	2 024	750	1 299
Cash expenses stock (birr yr^{-1})	332	293	209	187
Cash expenses PPU (birr ha^{-1} yr^{-1})	436	400	167	139
Cash expenses SPU (birr TLU^{-1} yr^{-1})	230	231	119	168
Total Cash Expenses (birr yr^{-1})	998	924	495	494

Table 24 Economic indicators Gobo Deguat and Teghane

In table 25 it can be seen that labour intensity of both sites is comparable for the different activities; most family labour goes into crop activities. Labour spent on livestock includes the collecting and preparing of feed, watering and milking.

In Gobo Deguat the farmers spent more time on off-farm activities than the farmers of Teghane. The off-farm labour in Gobo Deguat is mostly spent on Food for Work projects, which hard to join in Teghane. Both sites have little other off-farm labour opportunities. Even though Teghane is closer to larger towns and to the Afar region, off-farm labour opportunities are very scarce.

Returns to land vary a lot per household. The average returns to land give -305 birr per hectare for Teghane and 90 birr per hectare for Gobo Deguat, both being very low. Also on the returns to labour Teghane scores negative. In the average economic performance of the farm activities is thus better for Gobo Deguat but on average is still unsatisfactory.

	Teghane		Gobo Deguat	
	Mean	Stdev	mean	Stdev
Labour General (days yr^{-1})	74	74	6	15
Labour Crop (days yr^{-1})	262	208	211	142
Labour Livestock (days yr^{-1})	76	46	47	42
Labour Off-farm (days yr^{-1})	9	17	41	36
Total family Labour input (day $farm^{-1}$)	421	264	306	147
Hired Labour (days yr^{-1})	2	4	1	3
Labour Intensity crops (days ha^{-1} yr^{-1})	171	111	146	123
Labour intensity livestock (days ha^{-1} yr^{-1})	20	12	15	12
Returns to land (birr ha^{-1})	-305	2 624	90	2 378
Returns to labour (birr day^{-1})	-4	5	1	9
Returns to off-farm labour (birr day^{-1})	2	3	6	6

Table 25 Labour Activities Teghane and Gobo Deguat

Crop activity level

In table 26 the cereal crops that were cultivated at each site are compared . Barley in Teghane yielded an average of 2 076 kilogram per hectare with an external input of 10 kilogram per hectare of fertiliser. In Gobo Deguat the external fertiliser input was four times that of Teghane, 39 kilograms per hectare, but the average yield was only 617 kilogram per hectare. In Gobo Deguat black wheat on average had lower yields with higher mineral fertiliser input than Teghane, indicating how uncertain the extra benefits of mineral fertiliser use is in Gobo Deguat.

Faba Bean was not sold. Mineral fertiliser input for the pulse was minimal at both sites.Although faba bean is a leguminous crop it does show the most positive N-balance of all crops. Total organic N-input on faba bean has been higher for Teghane than for Gobo Deguat and this is reflected in total yield output. Faba bean had shown some crop failures in Gobo Deguat, because of waterlogging. Wheat in Gobo Deguat shows higher gross margins and a positive net cash flow. Cash receipts have been much higher in Gobo Deguat showing that it is sold more often than in Teghane. Variable cost on traction and mineral fertiliser also is lower in Gobo Deguat.

Total variable costs at both sites are comparable to each other and for all crops lie around 1 000 birr per hectare with variable cost for faba bean being an exception, being much lower in Gobo Deguat. Traction was the highest variable cost for Teghane, being more than double that of Gobo Deguat. The high cost for traction was related to the number of oxen owned.

	Barley		Black Wheat		Faba Bean		Wheat	
	TG	GD	TG	GD	TG	GD	TG	GD
	n=19	n=7	n=6	n=7	n=5	n=6	n=6	n=5
Area Crop (ha)	2,83	0,83	1,25	0,55	0,57	0,41	0,71	0,15
Yield (kg ha^{-1} yr^{-1})	2 076	617	1 035	860	1 841	473	2 066	1 328
Gross Margin (birr ha^{-1} yr^{-1})	4 490	2 535	1 267	2 799	2 827	1 683	2 932	5 842
Net Cash Flow (birr ha^{-1} yr^{-1})	360	-445	311	219	-143	-92	-371	620
Variable Cost (birr ha^{-1} yr^{-1})	-1 220	-985	-994	-1 393	-1 067	-489	-1 385	-1 530
Variable Cost Seed (birr ha^{-1} yr^{-1})	-392	-343	-279	-704	-360	-558	-365	-1 333
Variable Cost mineral Fertiliser (kg ha^{-1} yr^{-1})	-120	-377	-43	-163	-83	0	-297	0
Variable Cost hired labour (birr ha^{-1} yr^{-1})	-24	-13	-7	0	-41	-13	-2	-22
Variable Cost Traction (birr ha^{-1} yr^{-1})	-684	-252	-665	-527	-577	-220	-722	-176
Cash Receipts (birr ha^{-1} yr^{-1})	569	9	462	463	0	0	22	938
Cash Expenses (birr ha^{-1} yr^{-1})	208	454	151	244	143	92	593	317
N-balance (kg ha^{-1} yr^{-1})	-14	19	-15	-23	51	25	-11	-13
N-inflow Mineral fertiliser (kg ha^{-1} yr^{-1})	10	39	4	10	5	0	24	0
N-inflow Organic (kg ha^{-1} yr^{-1})	35	5	5	6	114	47	24	22

Table 26 activity indicators main crops Gobo Deguat and Teghane

Summary and Conclusions

The sample farmers of Gobo Deguat and Teghane show differences in the factors of income and nutrient balances. The sample farmers of Teghane are clearly wealthier in terms of assets, net cash flows and net farm income (NFI). Crop and livestock activities contributed in the same amount to the NFI in Gobo Deguat. In Teghane crop activities contributed significantly more to the NFI than livestock activities did. Gross margins per TLU were also higher in Gobo Deguat than in Teghane.

Variable costs on total do not differ that much at both sites but variable cost on traction is almost double for Teghane. It is however not correlated to crop yields. From this study there does not seem to be extra benefit from the extra traction, the amount of traction applied even shows a correlation to the amount of N-lost by erosion (OUT5). The extra traction could indicate a sign of social status, which is linked to the amount of oxen owned. To reduce variable costs it would be worthwhile to look at reducing this amount of traction. This will reduce energy required by the oxen and reducing the amount of feed input.

In terms of nutrient balances the farmers of Teghane scores better. There are a few logical explanations for this. The households in Teghane do not cultivate many steep slopes, also the organic a mineral N-input per hectare is a lot higher. As concluded earlier and again shown in table 26 it can be seen that returns on mineral N fertiliser are uncertain for the households in Gobo Deguat, crop outputs are not significantly higher with higher N-input. The sample farmers of Teghane show opportunities in the intensification of agricultural production with higher inputs. For the households in Gobo Deguat other forms of conservation methods have to be used.

Returns to land and labour are more positive for the sample farmers of Gobo Deguat than they are for Teghane. Teghane uses a lot of labour for the farm activities, lowering returns to land. For returns to labour capital costs of land turn out higher than the NFI for most farmers making the returns on labour negative as well. Capital cost of land is much lower in Gobo Deguat. For both sites returns on off-farm labour is higher than on farm labour. Creating off-farm opportunities would be help but it may not be realistic especially for Gobo Deguat.

Chapter 7 Summary of Results, Conclusions and Research Constraints

Introduction

Chapters five to seven dealt with the analysis of the results based on the research question raised in chapter one: What are the sustainable management opportunities at household level when compared to the factors of income and nutrient management, using results from the NUTMON-toolbox?

This chapter integrates and summarises the results from the foregoing chapters concerning the nutrient and income management aspects of the sample farmers. First the summary of the results and the conclusions are dealt with followed by research constraints and the discussion.

Summary of the Results and Conclusions

From the RDA and the NUTMON results an income analysis was made. For this section the indicators, for analysis on the income level of the sample households, are divided into a description of the available resources combined with the activities of crop, livestock and off-farm activities, analysing the factors land, labour and capital. This last part of the income analysis is a farm financial analysis evaluating the net farm incomes, total family earnings and gross margins. The Nutrient analysis is described through the N inputs and outputs into the farming system, the erosion rates per farm and per crop. The differentation in types of farmers are left out in this summary because the differences between them were not based on the initial idea of active and non-active farmer in Soil and water conservation.

Income analysis

The total area was divided into share cropped in land and land owned. The cultivated areas were fragemented over numerous plots spread over the kushet. The total area for the sample households in Teghane was 0,88 hectares and for Gobo Deguat 0,56 hectares. The average area cultivated was very little for Teghane it was 0,46 hectares and for Gobo Deguat only 0,29 hectares.

When comparing this to data made available by the tabia administration offices in 2002, the averages for Gobo Deguat were a total holding of 1,18 hectares and for Teghane a total holding of 1,44 hectares. This is clearly a lot more than the total holdings of the sample farmers. A reason could be that the total holding as recorded by the tabia administration includes the homestead, which I have not taken into account.

Share cropping in land was a way of increasing the area of cultivable land also been indicated in the RDA as a strategy for food security. Share cropping out land was only done by one female headed household. Share cropping out land has as a benefit that there

is no family labour input needed from the household, the labour can be put to use for other use for other activities. She obtained extra income from her husband who was in military service. Because of the little land she now cultivated and the already little livestock, all her children were able to go to school.

Labour market is poor, at both sites. The previous two years there have however been Food-for-Work projects organised by REST in Gobo Deguat. This has clearly increased food security and is reflected in increase in family earnings and higher returns to off-farm labour. In Teghane there is less off-farm work available. Food-for-Work (FFW) projects were only available to one of the sample farmers. In the RDA however the farmers indicated that the FFW projects were important activities, and there was quite some time spent on it, this could not be identified in the activities of the sample households for Teghane

The total capital value of all assets owned by the sample farmers was much higher in Teghane than in Gobo Deguat. Assets include livestock, equipment and land owned. The average number of tropical livestock units owned in Teghane was 4,26 and in Gobo Deguat 3,69. The averages over the kushet households, obtained from the tabia administration offices was 1,23 TLUs for Teghane and 1,05 TLUs Gobo Deguat. This would indicate that the sample households are 'richer' than the average household in the kushet. The level of mechanisation is very low at both sites.

The financial analysis concerning in and outflows has been done on crop activity level for the major crops cultivated by the sample farmers. Total variable costs turned out lower for Gobo Deguat. The highest variable cost at Gobo Deguat was seed and in Teghane the highest variable cost was traction. The NFI and family earnings did not differ that much per site. The NFI in Gobo Deguat was lower but with off-farm earnings the total family earnings became positive and turned out only little lower than for Teghane.

The gross margins showed that the profit on livestock activities for Teghane is very low compared tot the crop activities. Also cash flows on livestock and positive on crop activities on average were negative for the households of Teghane. In Teghane it became very clear that the cash flows turned out more negative when the household had higher capital value and NFI. This indicated that the richer households are willing to take the risk of negative cash flows. The poorer households were trying to keep cash flows positive by selling livestock.

In Gobo Deguat the differences between the crop and livestock activities are not that large. Gross margins are lower for livestock but the cash balance on livestock and crops are comparable. Large expenses on livestock often included the import of residues and large expenses on crops are the external inputs on mineral fertilisers. The returns on fertiliser input were related to yield increases in Teghane but in Gobo Deguat there was no relation found between the mineral fertiliser input and the yield output. Indicating the low benefits from fertiliser use. From the ten farmers in Gobo Deguat seven were using mineral fertilisers and Teghane all farmers were. On kushet level the percentage of households using mineral fertiliser in Gobo Deguat was 40 percent and in Teghane 82 percent. The sample farmers are thus showing a higher percentage of usage.

Conclusions that can be drawn from the results for **Teghane** on economic level are:

- Opportunities in Teghane lie in the intensification of agricultural land because infrastructure and market access are good and from the study returns on fertiliser use are positive and indicate potential in increasing the inputs.

- Highest potential lies in the irrigation area, because there is room for improvement. Most sample farmers were only growing one crop a season and only half of the potential irrigation area is used. Research should be done by looking at the constraints farmers have for not using the area more intensively.

- It is shown in the study that the richer farmers are willing to take risks and would be potential farmers for the import of improved technologies such as the use of improved seeds, fertiliser and better breeds of livestock. They are able to take the risk of the high investments and are able to wait for the returns that may be on long term basis

- The high fragmentation and the small plots pose constraints to increasing productivity. A strategy already applied by the richer farmers is share cropping in land.

- The smaller farmers however need the opportunity to leave farming as source of income and work off-farm. This is still a problem, which is not that easily solved. As can be seen from the study, opportunities for other employment lack.

- Livestock is a high cost to many farmers, like in Gobo Deguat they are used as a savings bank and therefore important to the smaller farmers. The large number of livestock puts high stress on natural resources because of high feed demand. It should be tried to look at reducing the number of livestock, this could be by trying to look at mechanisation opportunities and reducing the need of having oxen. One of the technologies that were suggested in the ICRA (1997) report is using a plough that would only need one oxen, or a plough that would need less ploughing rounds. These two technologies are interesting to investigate for the variable costs of traction are relatively high for the sample farmer in Teghane.

Conclusions that can be drawn from these results for **Gobo Deguat** on economic level are:

- Opportunities for the households of Gobo Deguat are slight, there is lack of infrastructure and market access is poor and creating off-farm opportunities do not seem very likely to happen in the short run.
- The food security level is still low, most farmers were not able to survive on their crop output alone and FFW and FFA were important contribution to the household food security.
- On short term basis food security may be achieved by offering more food for work or free food aid, but this is not sustainable and only is a short-term solution. Cereal yields have to increase if the farmers want to become independent from external food aid. Opportunities for yield increase here are the external inputs such as seed and fertiliser and also by looking if there is improvement possible in soil and water management. Hanfest showed to be a cereal that is high yielding and relatively low risk, and is therefore interesting for further research.

- Intensifying crop production does not seem like a solution because the costs are relatively high. Also with the low and unpredictable rainfalls and the small plots it is risky to invest in new technologies.
- From the analysis it could be seen that the sample farmers manage their farm with a short term view this means they are less willing to apply technologies that generated returns in the long run.
- The gross margins are low for livestock and expenses high especially on feed, but livestock is kept as form of savings bank when receipts on crops are low. An option would be to reduce the amount of large ruminants to reduce feed quantities needed. This will also reduce the stress on natural resources in the area.
- In the long run the best strategy may be to emigrate. This is one of the strategies that have been applied by already many households. The question is if there are enough migration opportunities and if policy in one way or another can facilitate this

Nutrient analysis

The N-balance in Teghane is positive. There is no need for extra inputs. Soil erosion levels are however high, higher than the soil formation rate which means a decrease in soil depth and loss of nutrient rich top soil. The nitrogen lost by erosion is partly compensated by external input however this is only one macro nutrient. Phosphorous and potassium are also important for the nutrient analyses.

For Gobo Deguat nitrogen losses are high, most of the N-loss is from erosion. The main cause is the steep slopes on which farmers cultivate. Only two out of the ten farmers had very high erosion losses of more than 80 tons per hectare, resulting in high average values. The high soil loss rates reduce soil fertility, the water holding capacity of the soil and coupled to this is reduction in yield and food security.

It should be realised that the soil erosion losses as measured by the USLE often give overestimations. Its database of the USLE is restricted to the US, on slopes where cultivation is permissible. It is also deficient on information on the erodibility of sandy soils.

When using the outcomes as presented by NUTMON the conclusions that can be drawn at both sites are:

- There was no correlation to the number of soil bunds or stone bunds and the NFI and the cash flows. Wealth is thus not related to the number of Soil and water conservation structures built on the plots
- There was no relation found between the nutrient management and the type of farmer experimental of active
- Soil erosion losses are high at both sites. However in Teghane the loss of N through erosion is compensated by external inputs. N-losses in Gobo Deguat are high.
- For Gobo Deguat best would be to reduce the pressure on the land, and stop or minimise cultivation on very steep slopes.
- From the study, increasing fertiliser use to increase te the nutrient concentration in the soil and available to the crops did not seem a very good solution. The fertiliser

did not give higher returns (that year). The risk in terms of cost and not benefiting from extra returns are too high for most farmers.

- From the erosion point of view, traction is a large cause of soil loss and from economic point of view it shows high variable costs. In Nyssen et al. (2000) it is concluded that on average, tillage erosion can be held responsible for half of the sediment deposited behind newly constructed bunds. Costs of traction should be tried to be reduced by reducing the amount of tillage operations or in finding new technologies where less animal traction is needed.
- Opportunities lie in improving the Soil and water conservation technologies present and maybe introducing new ones, especially true for Gobo Deguat were soil losses by erosion are high. Other techniques than soil bunds or stone bunds should be investigated for further research, because the plots get even further fragmented by mass mobilisation projects, making the plots very labour intensive and even less susceptible for use of new technologies.

Research Constraints

Time has been a major constraint. The NUTMON-toolbox is designed for monthly monitoring but because of the time constraint this was not possible. The relevant data over the cropping season (e.g. yields, yield prices, inputs, input prices etc.) was coming from survey questions to the farmers with a recall period of a year which gave some error in the data, because a lot of what the farmers told us, could not be validated in the field.

The sample farmers were to be a cross section of the community, but the selection was made by a key informant which may have given a biased cross section. The tabia administration data showed that the selected households differed from the average households in the kushets, on average number of household members, livestock and area.

Furthermore the number of female headed households in the sample size was too little because the average over the kushets was 44% for Teghane and 38% for Gobo Deguat. The data obtained from the tabia administration was only available after the study had been completed.

The amount of (empirical) data needed is considerable and essential for high quality results. The time constraint limited the number of sample farmers. A total of eighteen farmers were selected, which is not a significant amount for the region and it is therefore not justified to upscale the results. The results were interpreted for the identified household only, and may not be representative to the whole area. There were many constraints concerning the data input into NUTMON toolbox, because many assumptions had to be made to fill in missing data. This gave an error in the quantitative outcomes. Not only were there errors in the input also the models used within NUTMON have a certain degree of error. As indicated in the section above the USLE erosion model is known to overestimate erosion levels. The leaching models were not adequate for the climatic situation in Gobo Deguat and rainfall data had to be manipulated for the leaching model work.

Looking at economic flows, the prices were determined by the market prices as set in the monitoring year. Not all unit prices could be determined by using farm gate prices such as for products that were not traded or for which only transactions in kind were involved.

Values for land and certain crops were hard to get by and had to be approximated. All of the land is state owned and none the sample farmers were able to indicate a realistic value. Therefore values had been calculated using opportunity costs and multiplication factors that indicated the difference in land value between Teghane and Gobo Deguat. In Gobo Deguat values of crops, livestock, equipment and labour have been approximated using shadow prices that were calculated by making the assumption that the prices were two and a half times farm gate price. These assumptions are somewhat arbitrary, but are better approximates of the reality than using farm gate prices at both sites.

Discussion

For this research I have not been able to do an in depth study of all opportunities available and research their feasibility. Further research at larger scale should be done to make reliable pronouncements at regional level. However, the purpose of this research is not to discover statistically significant relationships or effects, but to discover practically significant relationships. Because it concerns essentially exploratory research, rather than a confirmative study, where a certain hypothesis has to be tested, a descriptive research design is appropriate (in contrast to an experimental design). The empirical data collected for this research will be used in future research by the project. The results and conclusions drawn give an indication where other research can start.

References

AMANUEL G., KÜHNE R.F., TANNER D.G., VLEK P.L.G (2000) Biological nitrogen fixation in faba bean (Vicia faba L.) in the Ethiopian highlands as affected by P fertilization and inoculation – Biol Fertil Soil (2000) 32: 353-359 Springer Verlag

BERHANU GEBREMEDHIN, SWINTON S.M (2000) Reconciling food-for-work project feasibility with food aid targeting in Tigray Ethiopia – Elsevier, Food Policy 26 (2001) 85-95

BEYENE ATAKILTE, GIBBON DAVID, MITIKU HAILE (2001) Understanding diversity in farming practises in Tigray, Ethiopia- Managing Africa's soils No. 24

BOND D.A (ED.) (1980) Vicia Faba Feeding value, Processing and viruses ECSC, EEC, EAEC Brussels, Luxembourg; Factors Affecting the nutritional Value of Field Beans (Vicia Faba) Eggum B.O. National Institute of Animal Science, Department of Animal Psychology and Chemistry, Denmark pp107-123

BOND D.A (ED.) (1980) Vicia Faba Feeding value, Processing and viruses ECSC, EEC, EAEC Brussels, Luxembourg; Field Beans (Vicia faba): Their Processing and Value in Foods and Feeds Simpson A.D.F. Rank, Hovis, McDougall, Research Ltd. UK pp 257-272

BOSCH H. VAN DEN, GITARI, J.N., OGARO V.N, MAOBE S., VLAMING J. (1998) Monitoring nutrient flows and economic performance in African farming systems (NUTMON) III. Monitoring nutrient flows and balances in three districts in Kenya- Elsevier Agriculture, Ecosystems and Environment 71 (1998) 63-80

BOSCH H. VAN DEN, JAGER A.DE, VLAMING J. (1998) Monitoring nutrient flows and economic performance in African farming systems (NUTMON) II. Tool Development – Elsevier Agriculture, Ecosystems and Environment 71 (1998) 49-62

CAPÉAU B., (2001) In defence of the excess demand approach to poor peasants' economic behaviour, Theory and empirics of non-recursive agricultural household modelling – Proefschrift Faculteit Economische en Toegepaste Economische Wetenschappen, Katholieke Universiteit Leuven

CORBEELS M, SHIFERAW ABEBE, MITIKU HAILE (2000) Farmers' knowledge of soil fertility and local management strategies in Tigray, Ethiopia – Managing Afica's soils No. 10

DESTA KELAY BELIHU (2002) PhD thesis Analyses of Dairy cattle breeding practises in selected areas of Ethiopia Landwirtshaf-Gartenerischen Fakultat der Humbolt Universitat zu Berlin

DEUGD M.; RÖLING N, SMALING E.M.A (1998) A new praxiology for integrated nutrient management, facilitating innovation with and by farmers – Elsevier, Agriculture, Ecosystems and Environment 71 (1998) 269-283

ESSER KJELL, VAGEN TOR-GUNAR, TILAHUN YIBABE, MITIKU HAILE (2002) Soil Conservation in Tigray, Ethiopia – Noragric Report No. 5, Noragric, Centre for International Environment and Development studies, Agricultural University of Norway (NLH)

FAO/WFP; (2001) FAO global information and early warning system on food and agriculture WFP, Special Report FAO/WFP crop and food supply assessment mission to Ethiopia

FAO/WFP; (2002) FAO global information and early warning system on food and agriculture WFP, Special Report FAO/WFP crop and food supply assessment mission to Ethiopia

FEOLI ENRICO, VEURICH G.L, ZERIHUN W. (2001) Evaluation of environmental degradation in northern Ethiopia using GIS to integrate vegetation, geomorphological, erosion and socio-economic factors - Elesevier, Agriculture, Ecosystem and Environment 91 (2002) 313-325

FRANZEL S., HOUTEN H. VAN (1992) Research with Farmers- lessons from Ethiopia – CAB international for Institute of Agricultural Research, Ethiopia

HAGOS F, PENDER J., NEGA GEBRESELASSIE (1999) Land degradation in the Highlands of Tigray and strategies for Sustainable Land Management.- Socio-economics and Policy Research Working paper No. 25, Addis Ababa Ethiopia

HAWTIN G.; WEBB C. (EDS.) (1982) Faba Bean Improvement- ICARDA Netherlands; 12. Symbiotic Nitrogen Fixation in Faba Beans, Hamdi Y. A. Department of Microbiology, Institute of Soil and Water Research, Agricultural Research Centre, Giza, Egypt (12):

HAWTIN G.; WEBB C. (EDS.) (1982) Faba Bean Improvement- ICARDA Netherlands; 13. Symbiotic Nitrogen Fixation in Faba Beans in Sudan, Musa M. Agricultural research Corporation, Wad Medani, Sudan (13):

ICRA Working Paper (1997) Coping with low and erratic rainfall in the Eastern Zone of Tigray: Proposals for participatory research and development with farmers. Ethiopia, 1997

IGAD/INTSORMIL/USAID-REDSO (2001) Agricultural Technology for the semiarid African Horn, Country Study: Ethiopia – INTSORMIL Publication 00-3-Volume 2

JAGER A. DE, KARIUKU I., MATIRI F.M., ODENDO M., WANYAMA J.M. (1998) Monitoring nutrient flow and economic performance in African farming systems (NUTMON) IV. Linking nutrient balances and economic performance in three districts in Kenya –Elsevier Agriculture Ecosystems and Environment 71 (1998) 81-92

JAGER A. DE, NANDWA S.M, OKOTH P.F (1998) Monitoring nutrient flows and economic performance in African farming systems (NUTMON) I. Concepts and methodologies – Elsevier Agricultures and Environment 71 (1998) 37-48

JAGER A. DE, ONDURU D., WIJK M.S VAN, VLAMING J., GACHINI G.N. (2001) Assessing sustainability of low-external-input farm management systems with nutrient monitoring approach: a case study in Kenya – Elsevier Agricultural Systems 69 (2001) 99-118

KASSA HABTEMARIAM, D. GIBBON, SINGH B.P (2002) Livestock Improve Household Food Security and Sustainability of Ethiopian Small Farms – Journal of Sustainable Agriculture, Vol 21(2)2002 The Haworth Press, Inc

KOSSORI, RADIA L. EL, VILLAUME C., BOUSTANI E. EL, SAUVAIRE Y., MEJEAN L. (1998) Composition of pulp, skin and seeds of prickly pear fruit (Opuntia ficus indica sp.) – Plant Foods for Human Nutrition 52: 263-270. Kluwer Academic Publishers

LUPWAYI N.Z., GIRMA M., HAQUE I (1999) Plant nutrient contents of cattle manures from small-scale farms and experimental stations in the Ethiopian highlands – Elsevier, Agriculture, Ecosystems and Environment 79 (2000): 57- 63

MEIJERINK G.W. (2002) Rural livelihoods and soil conservation in Eastern Tigray. A Rapid Diagnostic Appraisal Report for Gobo Deguat and Teghane. PIMEA Working Paper 2002-06. Wageningen UR.

MORGAN R.P.C (1995) Soil erosion and conservation second edition, Longman Group Limited 1995, UK

NYSSEN J, MOEYERSONS J., DECKERS J. MITIKU HAILE, POESEN J. (2000) Vertic movements and the development of stone covers and gullies, Tigray Highlands, Ethiopia - Z. Geomorph. N.F 44 2 145-164 Berlin, Stuttgard

NYSSEN J. (1995) Soil Erosion in Tigray Highlands (Ethiopia). I. Natural and Human Environment in its Relationship to Soil Erosion – Geo-Eco-Trop. 1995. 19(1-4) 51-82 Département de Géographie Physique Université de Liège, Belgique

NYSSEN J. (1997) Vegetation and soil erosion in Dega Tembien (Tigray Ethiopia) – Bull. Jard. Bot. Belg./Bull. Nat. Plantentuin. Belg. 66:39-62 (15-07-1997)

NYSSEN J. (1998) Soil and Water Conservation under changing socio-economic conditions in the Tembien Highlands (Tigray, Ethiopia) – Bulletin de la Société géographique de Liège, 35, 1998, 5-17

NYSSEN J; POESEN J; MITIKU HAILE, MOEYERSONS J; DECKERS J. (2000) Tillage erosion on slopes with soil conservation structures in the Ethiopian Highlands – Elsevier; Soil & Tillage Research 57 (2000) 115-127

RAMIREZ RICARDO (2000) Understanding Farmers' Communication Networks: Combining PRA with Agricultural Knowledge Systems Analysis – 2000 IIED Sustainable Agriculture and Rural Livelihoods

SAXTON, K.E., W.J. RAWLS, J.S. ROMBERGER, R.I. PAPENDICK. (1986). Estimating generalized soil-water characteristics from texture. Soil Science Soc. Am. J. 50(4):1031-1036

SHIFERAW BEKELE, HOLDEN STEIN (1999) Soil Erosion and Smallholders' Conservation Decisions in the Highlands of Ethiopia – World Development Vol. 27, No. 4, pp 739-752, 1999 Elsevier Science Ltd.

STONE R P; HILBORN D. (2000) Universal Soil Loss Equation (USLE) – Fact sheet, Queen's Printer for Ontario, Ministry of Agriculture and Food, Ontario, Canada http://www.gov.on.ca/OMAFRA/english/engineer/facts/00-001.htm

STOORVOGEL, J.J. ; SMALING, E.M.A. (1990) Assessment of soil nutrient depletion in Sub-Saharan Africa: 1983 - 2000 Wageningen: Winand Staring Centre

UPTON, MARTIN (1996) The economics of Tropical Farming systems – Cambridge University Press, Great Britain

WOLDEAMLAK A.; STRUIK P.C (2001) Mixed cropping of barley (Hordeum vulgare) and wheat (Triticum aestivum) landraces in the central highlands of Eritrea- Proefschrift Wageningen University

WOLDEHANNA T (2000) Economic Analysis and Policy Implications of Farm and Off-farm employment: A case study in the Tigray Region of Northern Ethiopia – Proefschrift Wageningen University

WOLDEHANNA T; OSKAM A (2001) Income diversification and entry barriers: evidence from the Tigray region of northern Ethiopia–Elsevier, Food Policy 26(2001)351-36

YOUNG JOHN (1997) Development and Change in Post-Revolutionary Tigray – The journal of Modern African Studies 25 I(1997), pp. 81-99 Cambridge University Press

Glossary

birr The currency of Ethiopia. The official exchange rate in 2001/2002 was US$1= 8,54 birr

FSU Farm Section Unit is a continuous field within a farm which is assumed to have homogeneous soil properties, slope, flooding regime and land tenure. It is used in the NUTMON toolbox for the calculation of erosion levels and total area. In practise it was comparable to the different plots owned by the Tigrinian farmer

Kushet It is the smallest entity, the village. The villages have a kushet administrator comparable to a village leader.

PPU Primary Production Unit used in NUTMON as crop activity consisting of one or various crops grown deliberately in one field (FSU).

REST Relief Society of Tigray an NGO active in Tigray. Goal of the REST program is to enhance agricultural production through improved extension services and expanded development of water resources for irrigation. REST works in close collaboration with local community structures and the regional government

RU A Redistribution Unit is an abbreviation used in NUTMON as a location within the farm where nutrients are collected or accumulated in the form of manure or household waste, and from where nutrient are redistributed over the farm. For the farmers of Tigray RU examples were stables and compost pits.

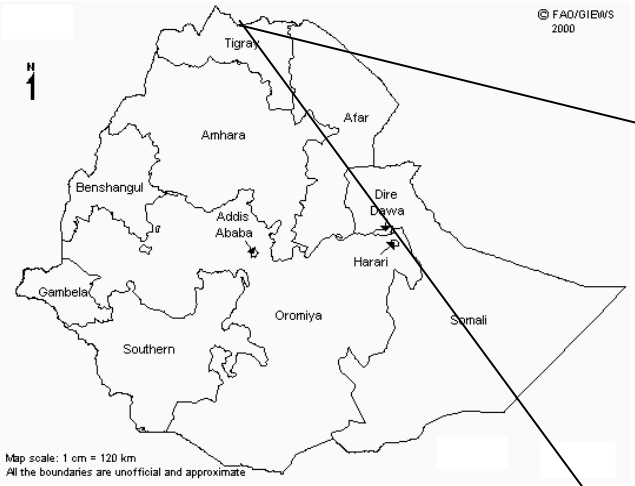
SAERT Sustainable Agriculture and Environmental Rehabilitation of Tigray.
SAERT specifically focuses on water resource development through the construction of microdams. These microdams are intended to bring permanent irrigated agriculture to the region. The dams are also afforested to serve as a source of fuel and to rehabilitate degraded watersheds and improve water supply.

SPU SPU is the abbreviation used in NUTMON for a group of animals of the same breed/species, managed by the farmer as a single group in terms of feeding, care herding and confinement.

Tabia Lowest administrative unit in Tigray consisting of 5-8 villages (kushets)

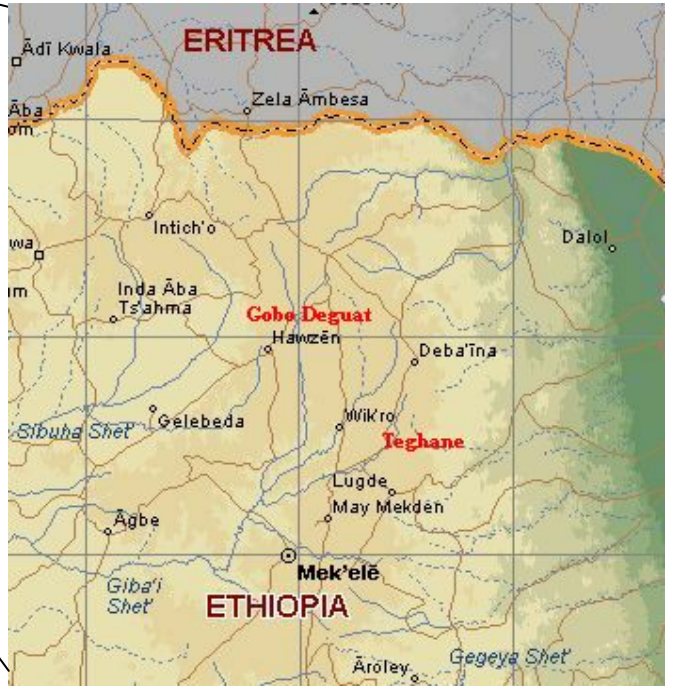
Woreda Is a district. The woreda is decentralized into smaller administrative levels, tabia and kushet level

Fout! De hyperlinkverwijzing is ongeldig.

Fout! De 

hyperlinkverwijzing is ongeldig.

Fout! De hyperlinkverwijzing is ongeldig.



Fout! De hyperlinkverwijzing is ongeldig.

Fout! De hyperlinkverwijzing is ongeldig.

Fout! De hyperlinkverwijzing is ongeldig.

Fout! De hyperlinkverwijzing is ongeldig.

The P values for the erosion control practice factor are obtained from tables of the ratio of soil loss where the practice is applied to the soil loss where it is not. No erosion control factor gives value 1.0. The tables are found in Morgan (1995) and tables are also available in the help function of the data entry module of the toolbox

Fout! De hyperlinkverwijzing is ongeldig.

Table I 2 Rainfall Data Teghane 2001-2002 (World Vision Atsbi)

Annex J Model Options

Description	Value
Default C USLE for annual crops	0.110
Default C USLE for perennial crops	0.050
Average depth above which the bulk of the soil organic matter is present [m]	0.400
Reduction factor for P and K losses by erosion because of soil formation [fraction] [0-1].	0.750
Avg. amount of household waste produced per consumer unit per day [kg]	1.000
Avg. number of labour hours per working day [hr].	8.000
Soil depth below which nutrients are supposed to be lost from the system [m]	0.900
Default fractional amount of DM in Manure as fraction of DM in Feed.	0.500
Multiplier to determine maximum intake of DM based on average daily dm intake per animal.	1.500
Fraction minimum feed requirement met.	0.500
Default N-gaseous loss from RU [fraction on yearly basis] [0-1].	0.300
Reduction factor for gaseous N losses from RU because of presence of Floor [fraction on yearly basis] [0-1].	0.000
Reduction factor for gaseous N losses from RU because of presence of Roof [fraction on yearly basis] [0-1].	0.500
Default K-leaching from RU [fraction on yearly basis] [0-1].	0.500
Default N-leaching from RU [fraction on yearly basis] [0-1]	0.300
Reduction factor for K-leaching losses from RU because of presence of Floor [fraction on yearly basis] [0-1].	1.000
Reduction factor for N-leaching losses from RU because of presence of Floor [fraction on yearly basis] [0-1].	
Reduction factor for K-leaching losses from RU because of presence of Roof [fraction on yearly basis] [0-1].	0.900
Reduction factor for N-leaching losses from RU because of presence of Roof [fraction on yearly basis] [0-1].	0.900
Soil Evaporation Factor for annual crops. [fraction][0-1]	0.400
Soil Evaporation Factor for perennial crops. [fraction][0-1]	0.200
Water Use Efficiency for C3 crops. [kg dry matter per kg water][0-1]	0.004
Water Use Efficiency for C4 crops. [kg dry matter per kg water][0-1]	0.006
Start year	2001
Include PPU flow IN3? (Atm. Dep.) (yes/no)	Yes
Include PPU flow IN4? (BNF) (yes/no)	Yes
Include PPU flow OUT3? (Leaching) (yes/no)	Yes
Include PPU flow OUT4? (Gas. loss.) (yes/no)	Yes
Include PPU flow OUT5? (Erosion) (yes/no)	Yes
Include RU flow OUT3? (Leaching) (yes/no)	Yes
Include RU flow OUT4? (Gas. loss.) (yes/no)	Yes
Include RU flow OUT6? (Latrine loss.) (yes/no)	Yes
Include irrigation water in leaching calculations? (yes/no)	No
Leaching model used: 1 = "Smaling", 2 = "DeWilligen"	1
Livestock excretion model preferred: 0 = no preference 1 = "fixed amount/quality", 2 = "conversion", 3 = "balance".	0
Livestock uptake model used: 1 = "Dry matter", 2 = "Energy"	1